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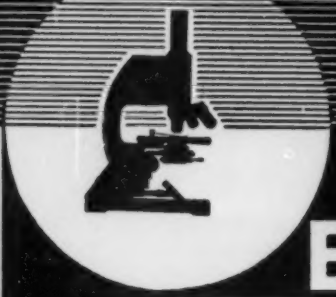

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NUMBER 5
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Science Education

SOME NOTES ON SCIENCE TEACHING IN ENGLISH SCHOOLS

GEORGE W. HUNTER
Claremont Colleges, Claremont, California

HOW TO SEE ENGLISH SCHOOLS

It is obvious that a visitor who spends only part time of three months visiting English schools cannot hope to obtain more than a broad over-view of a very complex school picture. Nevertheless, if he knows what he wants and how to get it, he will leave England with some very vivid impressions. My impressions of the science curriculum and science teaching in the English secondary schools are passed on in the hope that some of the readers of this article may be fortunate enough to duplicate or improve on these experiences.

A suggestion to the prospective visitor is worth making at the start. Obtain credentials in advance from your state department of education and, if possible, from the Bureau of Education at Washington. A big red seal goes a long way as an "open sesame" in the government-aided schools. Present your credentials at the Board of Education at Whitehall in London where visits will be planned for you in advance. One does not casually enter a school building in England; he must be invited. If you want to see the inside workings of the English Public School, you had best contact one of the "old boys." A personal introduction to the Headmaster will give you the rare opportunity of going into the classrooms and talking with the masters. But here again you must plan your visit some days before you wish to make your tour of inspection. The English-Speaking Union, Dartmouth House, 37, Charles Street, Berkeley Square, W. 1, London, or the National Union of Teachers, Hamilton House, Mabledon Place, W. C. 1, London, may be able to help.

If you are fortunate, you will rent a small English car, plan your itinerary in a general way, and then trust to the weather. You will always find a comfortable inn for the night. Driving distances are so short that you may stop as long as you wish, when the spirit moves, and still reach some destination that is just as good as another. Our trip, which started at London early in May and brought us back again in the middle of July, took us through the cathedral towns as far south as Plymouth, along the west coast *via* Bath, Bristol, Oxford, Stratford-on-Avon, and Worcester into Wales, then by way of Chester, Liverpool and the English Lakes north into Scotland as far as Oban and Inverness and back through the eastern cathedral cities, the fen district and Cambridge to London. On our way, besides glimpsing some thirty-odd cathedrals and abbey churches and nearly as many more ruined castles or medieval abbeys, we had time to visit ten of the government-aided secondary schools, six of the Public schools, two technical colleges, and the educational departments of half a dozen universities.

THE STRUCTURE OF THE ENGLISH EDUCATIONAL SYSTEM

As the reader doubtless knows, the structure of the educational system in England

differs considerably from that of this country. Up to less than forty years ago a large part of the educational burden was upheld by religious bodies, wealthy individuals and voluntary societies, and in part by local "rates" or taxes. In 1899 a central governmental authority was established by enactment and in 1912 the Balfour Act brought elementary, secondary and technical education under the scope of both Local Educational Authorities (commonly known as the L.E.A.) and a Central Authority.[1]

The central authority for England and Wales is the Board of Education. The head of this board has a seat in the Cabinet as Minister of Education. The department is permanently staffed by a body of administrative officers with a Permanent Secretary as their head. Their offices, including an excellent pedagogical library, is located at Whitehall. In addition to the London staff there are groups of field inspectors who report back to the central office on the conditions in various schools visited in England and Wales.

The Board does not directly control any educational institution (except the Royal College of Art). It does not employ teachers nor does it prescribe texts or courses of study. Its functions are simply advisory and in schools over which it exercises control it contributes about one-third of the total expense of the school.

The local educational authorities consist of sixty-three Councils of Counties, eighty-three Councils of County Boroughs, one hundred and thirty-five Councils of other Boroughs and thirty-five Councils of Urban Districts.[2] Each local educational authority turns over the purely educational work to an educational committee of persons who presumably are interested in and qualified to deal with educational matters. This committee must include women as well as men.[2]

[1] *Educational System of England and Wales.* H. Ward, Cambridge University Press, 1935.

[2] *An Outline of the Structure of the Educational System in England and Wales.* Board of Education Educational Pamphlets, No. 9, London, 1934.

The financing of the schools is carried on by local taxes or "rates" which are levied by the local authorities. In 1933 the amount derived from local rates for England and Wales was £40,000,000, while the central authorities provided £42,000,000. In financing the secondary schools a third factor enters. Under new regulations which came in effect in April, 1933, all secondary schools are required to charge tuition fees. This charge varies, amounting from ten to twelve pounds a year, which is roughly one-third of the total cost of individual maintenance. Nearly one-half of the students in state-aided secondary schools pay full fees, the remainder obtaining scholarships.

The support of voluntary bodies, such as established foundations, churches, or private benefactions, plays a much more important part in English education than in this country. Such bodies provide for nursery schools, special schools, Public elementary and secondary schools, technical schools, training colleges, and adult education classes. Schools provided by voluntary bodies may be (1) entirely financed by a Local Education Authority; (2) aided by such an authority; (3) secure direct financial aid from a Central Authority; or (4) entirely self-supporting.[3] The great English Public Schools are examples of the last named group.

SCHOOL ATTENDANCE

England, with a population of about 40,000,000, has an elementary school attendance in some 11,000 "provided" or government-aided schools of 3,800,000 and in 11,000 "voluntary" (Anglican and Roman Catholic) schools an attendance of about 1,800,000; a total of around 5,600,000. In 1930 with a population nearly three times as great the United States enrolled some 23,588,479 in her public elementary schools. If we allow roughly

[3] *An Outline of the Structure of the Educational System in England and Wales.* Board of Education Educational Pamphlets, No. 9, London, 1934.

twelve per cent[4] of the school enrollment for the parochial and other church controlled schools in this country, we have approximately 27,000,000 children of elementary school age enrolled, or almost twice as many for the population.

Figures for the government-aided secondary schools show even greater differences. In 1932–33 there were 441,833 children enrolled in the English secondary schools, or eleven per thousand.[5] In 1934, in the United States, the secondary school enrollment was thirty-three per thousand, just three times as many. Even allowing for the large number enrolled in vocational schools, evening institutes and the technical continuation schools (a total enrollment of about 1,000,000 students), the number in school is greater per unit of population in this country than in England. This fact probably accounts in part for the greater seriousness with which the boy or girl in the English secondary school takes education. Another factor comes through the entrance examination. The youngsters entering the English secondary school are a picked group, having obtained entrance to the schools by means of a series of rather rigid examinations. This can be seen by glancing at the statistics given by the London County Council.[6] The elementary schools in 1934 had an average daily attendance of 540,076 pupils while the central schools (roughly analogous to our junior high schools) had an attendance of 29,250. The secondary schools, which represent our senior high school through junior college, had a total average daily attendance of 38,035, or 8.3 per 1000 of population.

TYPES OF SECONDARY SCHOOLS

Under the English definition, a secondary school is one that "provides a full time education of a general, as distinct from a vocational character, for children from about eleven years of age to about seventeen years or more." The County Schools, so called because they are maintained by the County Councils, form the majority of the government-aided schools. But there are also many day schools, established on ancient foundations. These schools, such as the Pate Grammar School at Cheltenham, founded in 1578, receive government aid. In addition there are many private schools, the property of corporate bodies of individuals. These schools, which total perhaps 300,000 pupils, are not inspected by government officials and hence do not receive aid. Finally there are the great Public Schools, so called because the older of them were originally endowed for the benefit of the public. Some, such as Winchester (founded in 1382), Eton (1440), Westminster (1560), Rugby (1567) and Harrow (1571) are very old foundations, but there are others of much more recent date, such as Marlborough, Stowe, Bradfield, or Wellington. None of the one hundred fifty-odd public schools receive state aid. Winchester, Eton and Harrow and others have large and lucrative endowments and are housed magnificently. All are boarding schools and many have preparatory departments for the first four forms. Staunton says of the English endowed school, "No original, no counterpart, nor copy of it is to be found abroad; and it bears no resemblance to any foreign institution, under whatever denomination, where boys are assembled for the purpose of education."[7]

Every secondary school which receives state aid is inspected by the Board of Education and some private schools at their own request receive inspection. Practically all secondary schools, whether they receive aid or not, charge student fees, which are remitted in the case of scholarship students. In the City of Oxford School for Boys, for example, the fees are about $30.00 a term,

[4] Douglass, A. A. *The American School System.* Farrar and Rinehart, 1934.

[5] *Fundamental Statistics 1933–34.* London County Council, London, 1935.

[6] *Ibid.* Tables 3, 4, and 19.

[7] Staunton, H. *The Great Schools of England.* Sampson Low, Son and Marston, London, 1865.

and of the 253 boys, 127 are on scholarship.[8] While this proportion varies greatly in the individual schools, it is evident that the scholarship is an incentive to better work and largely accounts for the seriousness of the students as compared with the average American high school boy or girl.

EXAMINATIONS

As most of us are aware, the English school system is examination ridden. The examinations in English and arithmetic given between the ages of ten and eleven are in part tests for entrance to the secondary schools, but may also serve to qualify the candidate for an entrance scholarship. There are also examinations given for entrance to the Public schools. These include Latin, algebra, arithmetic and geometry, and are usually taken by boys in the private preparatory schools at the age of about thirteen. But the curse of the government-aided English secondary school, according to most of the masters with whom I talked, are the two examinations, imposed by the Secondary School Examination Council and conducted by eight approved University examining bodies in England and Wales. The first examination, or "School Leaving Certificate," is taken at about the age of sixteen by pupils from all types of private and state-aided schools. The three main groups of subject matter are English, foreign language, plus mathematics and science. A fourth group of electives is also taken, excellence in this chosen subject being allowed to compensate for low grades in one of the required subjects.

This group of examinations under certain conditions exempts the student from the matriculating examinations of the universities and from the preliminary examinations for certain of the professions. Since a large proportion of the boys who leave secondary school go into business or trades (only 6.8 per cent of all secondary school children in England and Wales entering universities in 1934), this type of test seems rather out of place, since it is obviously a preparation for University or the professions. A second comprehensive examination, known as the "Higher Certificate," is taken about the age of eighteen and is accepted by some universities as the equivalent of the *Intermediate Examination* for a university degree. These examinations vary, depending on the part of the country in which they are given. Those set by the Oxford and Cambridge Joint Board or by the University of London seemed to me much more conservative and difficult than those set by the University of Liverpool or the Joint Board of the Northern Universities. For example, the examinations in elementary science set by the University of London for the "Leaving Certificate" consisted of two alternative papers: one a three-hour examination in one or more of the following: botany, zoology, biology or geology, physics and chemistry; the other, called the elementary science examination, consists of two two-hour papers in (a) soil science, (b) domestic science or (c) biology. This examination included practical laboratory tests which would sorely try the average senior of our four-year high school. The "Higher Certificate" examinations in science were three-hour papers in physics, chemistry and botany, zoology or biology. The subject matter covered was placed on a plane of difficulty that in my judgment would be more than our average junior college student could master. The examiners expect clear and concise, but correctly scientific answers. Most of the questions are of the essay type and require highly specialized knowledge, based on laboratory experience. In the higher botany, zoology and biology examinations practical work is given in dissection and examination of parts of plants with reference to their systematic position, while in zoology the practical examination covers microscopic work, dissection, and classification. In the practical examination

[8] School List, 1935–36. City of Oxford High School for Boys.

in biology more emphasis is placed on physiological processes, embryology, and microscopic examination of unicellular forms, plant and tissues, *etcetera*. The whole examination system impressed me as being extremely formal with emphasis on the academic and pure science phases rather than on socially applied material.

NO SCIENCE SEQUENCE

The English believe in a solid foundation of pure science and do not understand our secondary school point of view in which a sequence of science is developed. While there are "progressives," the rank and file of the educators in the secondary schools are strongly conservative. Instead of a sequential arrangement of science courses so characteristic of our junior and senior secondary schools,[9] any one or all of the physical, chemical or biological sciences are taught during the seven forms of the secondary school. In the Mannamead School at Plymouth, for example, general science, consisting of elementary physics and chemistry, is taught in the first form for two periods a week. This is followed in the second form by elementary physics three periods a week. In the third form physics has two and chemistry three periods per week. In the fourth form physics has three and chemistry three periods per week, while in the fifth form physics has four and chemistry has four periods per week. This prepares for the "School Certificate" examination. If the boy goes to the University, in his sixth and seventh forms he has two years more of chemistry and physics in preparation for the higher examination. No biology is given. All work centers in the passing of the physics or chemistry examination. The boys worked in small groups or individually at their physics problems, their product being of a high class. The masters wished for more freedom in examinations, especially the "School Leaving Certificate." They believed that much of the work done in the upper forms duplicated that of the University, a complaint I have heard repeated on this side of the water.

In St. Georges Secondary School at Bristol, a rather large school of five hundred boys, general science, consisting of two hours of biology and two of physics, was given in the first form. In the second form one and a half periods of biology, half a period of physics, and two of chemistry were given. In the third form two periods of physics, while fourth, fifth and sixth forms devoted all science allotment to chemistry.

In the Pate Grammar School at Cheltenham, the science work was outstanding. Here three years were given to biology in the third, fourth and fifth forms, two, four and six periods per week. Chemistry was taught in the higher forms, the lads doing work in quantitative and organic chemistry of a very high type. The head biology master, H. Alan Peacock, impressed me as being a most progressive man. He believes in biology as a cultural as well as a practical subject. He has worked out a syllabus acceptable to the examining bodies of the Universities, yet quite different from the other organized syllabi that I examined. His point of view is a broad physiological base, preceded by a general survey of the natural history of living organisms. He is a firm believer in the field and museum excursion and in motivation through field clubs and other outside group meetings. He is the author of a recent book[10] on the teaching of biology which all readers of this article should peruse, for it gives a picture of the more progressive work in biology in English schools.

In Chester, the City and County Secondary Schools for Girls and Boys were in the same campus but had quite different curricula in science; physics and chemistry were emphasized for the boys and biology and human physiology for the girls. Here

[9] Hunter, G. W. "Science Sequence in Junior and Senior High School." *School Science and Mathematics* 33: 214–233; February, 1933.

[10] Peacock, H. A. *Biology in the School*, William Heinsmann, London, 1937.

again my strong impression was that teachers would welcome any change that would relieve them from the emphasis on examination. It was also evident here, as in other schools in northern England, that the examinations set by the northern group of Universities were much more liberal than those imposed by the Oxford and Cambridge or the University of London groups.

A similar condition was seen in the King James Grammar School at Knaresborough, a quaint little town perched on a hillside overlooking the river Nidd. Here an old grammar school foundation is housed in fine new buildings. The science curriculum emphasized the biological sciences, with stress on agriculture, although as one of the masters complained, "the syllabus had to be followed." One of the younger masters here had introduced with excellent results elementary human physiology instead of general science for the first formers. Conditions here reminded me of a similar situation in New York State some thirty years ago when teaching was so thoroughly dominated by the New York Regents syllabi and examinations.

In London at the City Council School for Boys, a rather large school with five science masters, the work was all of the university preparatory type. In forms two to six chemistry and physics were emphasized, the biology being as advanced work in the seventh and eighth forms. The latter subject, given to a small group of boys, was about the grade of good junior or senior college work in this country.

In the Streatham County Secondary School for Girls, an interesting modified Dalton plan was in operation. Here the school day is divided into eight periods of from thirty-five to forty minutes each. The first two morning periods and all three afternoon periods are used for teaching, while from 10:35 to 12:30 there is a free study period for most of the school. Each mistress stays in her own room, classes report there and during free periods the girls from all forms may come to the room for help or study. Each girl is given a syllabus of work to be done each month in each subject, no distinction being made between work done at home or in the free periods or in the classroom. There are four mathematical, four French and four science mistresses, so that it is possible to have fast and slow divisions in the various subjects. Thus a girl may be in a fast division in French, a moderate one in science, and a slow division in mathematics. The science program had the following time allotment.

First form—General Science, 2 periods per week plus free periods.
Second form—Biology, 2 periods per week plus free periods.
Third form—Physics and chemistry, 4 periods per week plus free periods.
Fourth and Fifth forms—Choice of biology, physics, chemistry or general science, 4 periods per week plus free periods. Examination in general school certificate at end of fifth form.
Sixth and Seventh forms—Student may take two or three sciences for higher certificate.

This was a very progressive institution and showed a program more nearly approaching the American secondary school than any other school visited.

It is evident from this sampling of state-aided secondary schools that no well defined sequence is seen. Perhaps a more intensive study would reveal different findings, but in all events a different standard exists here from that in our schools, emphasis being placed on thoroughness and knowledge of one subject rather than a broad over-view such as is being stressed at the present time in this country.

Another difference between English and American secondary schools is in the time allotment given to science. A student in the English secondary school not only devotes more time to science because of its position as a core subject, but he also has more intensive work in one specialized science, rather than getting a smattering of several sciences or perhaps none at all, as is the case in many American secondary schools above the junior-high grades. The average

boy in the English secondary school, between the ages of twelve and sixteen, spends eight forty-five minute periods per week on science subjects, of which three periods may be given to physics, three to chemistry, and two to biology. Of course this allotment of subject matter varies in different schools, frequently the entire time being devoted to either physics or chemistry.

(To be concluded in January issue)

A NEW METHOD OF DEMONSTRATING THE PRODUCTION OF OXYGEN BY A PHOTOSYNTHESIZING PLANT*

ABRAHAM RASKIN

Junior High Schools, New York City Public Schools

In his relatively short career as a teacher of science, this reporter has found few demonstrations which have proved so outstandingly unsuccessful as the experiment designed to show the production of oxygen by elodea under a glass funnel.

The writer experienced a desire to learn something of the history of the elodea experiment. An afternoon at the library yielded the following. The earliest mention of the experiment found was made by Wood in his *Class-Book of Botany* published in 1861.[1] He suggested that his students perform the "experiment of Saussure." His directions were:

"Place a quantity of freshly gathered leafy stems under a bell-glass full of rain water, and thus expose them to the sun. Soon bubbles of gas arise and slowly collect above, pure oxygen gas, as long ago proved by Dr. Priestley."

Wood cautioned his student against the use of boiled or distilled water in this experiment, realizing evidently that these liquids would have too low a concentration of carbon dioxide. Another suggested experiment read:

"Enclose air-tight in a glass globe the end of a leafy branch, without severing it from the tree. Thus it has been found by careful analysis after a day of sunshine that the proportion of O was increased at the expense of CO_2 within the globe; and *vice versa* by night or in the shade."

It is interesting to note that Wood's suggested experiments contain no directions for testing the gas obtained. The student experimenters were asked to believe that the gas was oxygen.

A similar experiment was suggested by Hooker in a text[2] published in 1884. In his text, Hooker suggested placing watercresses in a large bottle filled with fresh spring water and inverting the bottle into a large bowl of water. His directions do not include a technique for testing the gas obtained. He asked his students to look for bubbles of pure oxygen on the leaves and at the top of the bottle.

The first mention of an experiment found which included directions for testing the gas produced in photosynthesis with a glowing splint was discovered in Miss M. C. Stopes' *The Study of Plant Life for Young People,* published in 1906. The experiments suggested included the use of elodea and a glowing splint.

An attempt was made to trace the name of "Saussure" mentioned by Wood. The man referred to was undoubtedly Theodore, sometimes Nicolas,[3] de Saussure, a bio-

* Paper read before the Science Round Table of the Junior High School Conferences, New York City, March 20, 1937.

[1] Wood, Alphonso. *Class-Book of Botany.* New York: A. S. Barnes and Burr, 1861. p. 157.

[2] Hooker, J. D. *Botany.* New York: D. Appleton and Company, 1884. p. 113–114.

[3] Miller, E. C. *Plant Physiology.* New York: McGraw-Hill Book Company, Inc., 1931. p. 429.

physicist of the last century.[4]

Priestley, Senebier and Ingen-Housz are given credit[5] for first demonstrating the production of oxygen by a photosynthesizing plant. De Saussure made the first quantitative determinations in this field.

Several methods are used at present for detecting and studying the production of oxygen in photosynthesis. Spoehr[6] has classified the different techniques as follows:

1. *The use of the leucobases*—This experiment[7] consists of placing a water plant in water under a film of oil. The plant is placed in the dark until all the oxygen is used up. After a time leuco methylene blue or another leuco dye is added to the water and the plant is placed in the sunlight. The liberation of oxygen is shown by the formation of light-colored dye close to the plant.
2. *The luminous bacteria method.*
3. *The motile bacteria method.*
4. *The optical properties of hemoglobin method.*
5. *The bubble counting method* (This method was first used by Dutrochet in 1837).
6. *The gas analytical method.*

The production of oxygen by a photosynthesizing plant may be demonstrated by means of a projection lantern, projection cell and elodea. The bubbles of gas produced by the elodea can easily be seen on the projection screen.

Ambitious laboratory assistants and teachers of science have tried to improve the established techniques involved in the elodea experiment by adding soluble carbonates to the water in which the plant is submerged or by using carbonated water. Others have tried different types of irradiation. In a recent letter to the writer, Dr. Otis W. Caldwell of the Boyce Thompson Institute recommended

"that the inverted funnel commonly used in such experiments ought to be placed well above the plants but still within the water in order that oxygen may be collected."

The writer has tried this experiment with the suggested improved techniques many times. On one occasion Vita-glass was substituted for the customary Pyrex (even though the writer knew that the rays which are efficacious in photosynthesis are far removed in the electromagnetic wave series from ultra-violet rays). The writer and one of his colleagues, S. J. Weiss, have tried the method of continued radiation without very much success. Bubbles of gas were obtained, but one was never too sure that the gas was not air driven out of solution by the warmth of the radiating source. Satisfactory results with a glowing splint were never obtained.

The writer while a member of a science teaching seminar performed a series of computations[8] with data taken from Spoehr's *Photosynthesis* with the purpose of ascertaining how much oxygen was actually produced in photosynthesis. The following conclusions were drawn:

1. Photosynthesis is a very inefficient process. Only 0.66% of the total energy absorbed by a typical plant, *Helianthus annuus,* is used in photosynthesis. (Brown and Escombe.)[9]
2. One square centimeter of this plant produces 0.000337 cubic centimeter of oxygen per minute.
3. Even with the use of a large leaf surface (20 square centimeters) over 36 hours of continuous exposure are required to produce 15 cubic centimeters of oxygen, enough to give a qualitative test.
4. The amount of oxygen produced in one teaching period is much too small to give a good test. Obviously, therefore, if the demonstration is to be successful, the plant used must be irradiated either by direct or indirect sunlight or by an artificial source for a long period.

The writer several months later heard Dr. Morris Meister, Director of Junior High School Science in the New York City

[4] de Saussure, Theodore. *Recherches chimiques sur la vegetation.* Paris, 1804; or de Saussure, Theodore. *Chemische Untersuchungen über die Vegetation,* übersetzt von Dr. A. Wieler, Ostwald's Klassiker, No. 15 und 16, Leipzig, Verlag von Wilhelm Engelmann, 1890.

[5] Stiles, W. *Photosynthesis.* London: Longmans, Green and Company, 1925.

[6] Spoehr, H. A. *Photosynthesis.* The Chemical Catalog Company, Inc., 1926.

[7] Miller, E. C. *Loc. cit.* page 431.

[8] Raskin, Abraham. "How Much Oxygen is Produced by Ordinary Photosynthesis?" *The Teaching Biologist,* 5: 82; February, 1936.

[9] Brown and Escombe. *Proc. Roy. Soc.,* 76B, 69(1905), as reported by Spoehr in his "Photosynthesis."

Schools, in a session of his "Teaching of Science in the 7th, 8th and 9th Years" suggest a different type of demonstration designed to prove that plants produce oxygen in photosynthesis. Dr. Meister's experiment involved the use of a land plant sealed under a bell jar together with a candle. The oxygen inside the bell jar was to be partially exhausted by lighting the candle and closing the bell jar. After a period of irradiation the bell jar was to be uncorked and a glowing splint quickly introduced. It was recommended that this device be used with a control bell jar.

This type of experiment seemed satisfactory enough, but even the momentary opening of the bell jar in order to introduce the glowing splint seemed to bar the demonstration from perfection as a teaching device. The writer then decided to find a method of starting a combustion in the bell jar while it was completely sealed. A spark-gap induction coil system seemed like a satisfactory solution. But this method involved the sealing-in of wires and the possibility of air leaks. It was then decided that the most satisfactory source of combustion was the cigarette lighter.

The complete apparatus consisted of the following parts:

1. *A heavy one-fourth inch battleship-linoleum baseboard on which to seal the bell jars.* The problem of finding a suitable material for this purpose offered a bit of difficulty. After a few tests, wood was discarded because of its tendency to warp. Sheet bakelite was found to be very satisfactory. However, this material is quite expensive. The battleship linoleum finally decided upon is ideally suited for the purposes of this device. It is inexpensive, very smooth, water-proof and non-porous.

2. *Two round wooden discs which are cemented to the baseboard.* Each disc holds the bottom part of a lighter, a candle-holder and a candle. The discs were cemented to the baseboard, instead of being nailed, to prevent the possibiilty of air leaks.

3. *Two long slender wire rods* to each of which *was soldered the top portion* of a *lighter and a coil-spring candle holder.* The wire used was cut from a hoop used to hold the staves of a barrel together. The top of each rod is bent over into the form of a long U.

4. *The bell jars, each sealed at the top with a rubber glove.* A small-sized rubber glove was fastened across the top of the bell jar with fishing line and beeswax. Care must be taken to ascertain that the seal is airtight. The seal of the bell jar to the baseboard was made airtight with petroleum jelly.

5. *A photosynthesizing plant with a large leaf surface.*

6. *A desk lamp equipped with a 100-watt bulb.*

Two types of lighters were found which seemed to be satisfactory for use in the device. The Ronson or Evans type of lighter is easily manipulated from above a sheet of rubber or a rubber glove stretched loosely across the mouth of a bell jar by means of a long slender wire rod. A palladium-wire type of lighter, the Master-Lite,* was found to be very satisfactory. This lighter is operated by lifting the top or palladium-wire end of the lighter from the base and inserting it into the receptacle in the base which contains an atmosphere of methanol. On withdrawing the methanol-laden palladium wire from the base, the wick saturated with the methanol bursts into flame. In the set-up described above, the top part of the lighter is soldered to the long piece of stiff wire which is worked from the outside of the bell jar through the fingers of the rubber glove which forms the top seal of the jar.

The operation of this device is quite simple. The plant is sealed under the bell jar with vaseline and the lighter is used to ignite the small candle which is used to light the large candle. The two candles are used in order to make the combustion more easily visible in a large classroom. After a time the candle goes out. The plant is then irradiated for 24 hours or more. At the end of this period, an attempt is made to light the large candle in the same way as at the beginning of the demonstration. In some cases, continued irradiation may be necessary. The procedure outlined above is followed in the case of the control bell jar too.

This device has been tried once with nepthytis, a large-leaved plant. With a leaf

*This lighter may be obtained by sending 25 cents to New Method Manufacturing Company, Bradford, Penna.

surface of approximately 100 square centimeters and a 56-hour period of irradiation, fairly satisfactory results were obtained. The writer, despite the theoretical soundness of the demonstration, hesitates to recommend the device until uniformly satisfactory results are obtained with many plant species. Dr. Caldwell has recommended the tomato plant and bryophyllum as fairly active land plants. A member of the botany department of Columbia University has suggested that any plant with a large leaf surface should prove satisfactory.

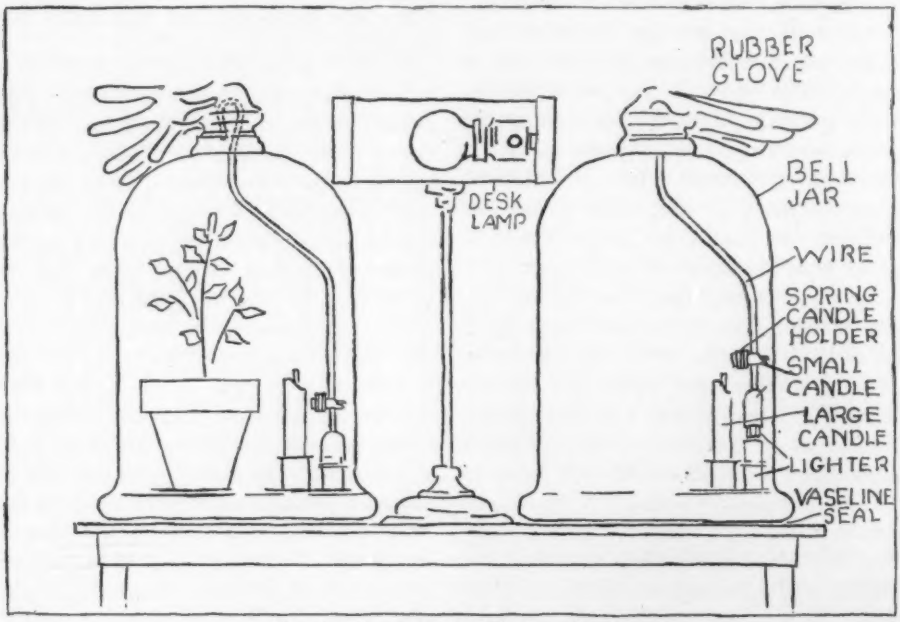

FIG. 1.—Apparatus for Photosynthesis.

Further experimentation with different types of lighters is necessary. The writer recently came upon a lighter, the Strike-a-Lite, which may obviate the use of the two candles.

Another type of experiment which seems worthy of further trial is a combination of the demonstration projection method, previously mentioned, and the leuco-methylene blue technique. If elodea or cabomba are kept in the dark for a day or two and then placed in a projection cell under a film of oil, bubbles of gas will be seen rising from the plants. In order to prove that the gas is oxygen the colorless leuco-methylene blue can be injected under the film of oil with a hypodermic and the color change noted as the oxygen oxidizes the dye stuff and turns the water light blue in the neighborhood of its production. If the dye suggested is difficult to obtain, other leuco dyes such as leuco-indigo carmine or leuco-malachite green may be substituted. The writer intends to devote some time to experimentation with these dyes and will report when a technique suitable for secondary school use is evolved.

The writer wishes to express the hope that this paper will be of some use to the teachers of science anxious to improve the established techniques for demonstrating the production of oxygen by photosynthesizing plants.

WHY NOT TEACH THE SCIENTIFIC METHOD?

PHILIP B. SHARPE
Greenwich High School, Greenwich, New York

The scientific method* is more precious to the human race than a collection of scientific facts; just as the proverbial goose was more precious than a golden egg.

The scientific method is only about 400 years old, but it has already produced billions more facts and inventions than all the previous 400,000 years of human progress. What present scientific facts have done to our world, we see; what the scientific method will do to the world of the future staggers the imagination.

We live in a world of scientific progress. That progress would cease with the drying up of the very fountainhead of scientific progress, the scientific method. And we can profit from it not only vicariously but also personally, as the scientific method is open to all, simple to understand, and applicable to many personal problems. Science is yet in its infancy.

In most cases science pupils learn many scientific facts but do not assimilate the scientific method of solving problems.

A perusal of many science texts fails to yield simple, clear expositions of this method. Many of those examined do not even attempt one. Those that do are generally excelled by the encyclopedia. One has yet to find real practice in the use of the scientific method incorporated in typical secondary texts, workbooks, or even laboratory manuals. In fact a great many college science students can be paralyzed, at least momentarily, by being asked to explain this method, or even to tell why a control is necessary in an experiment.

The results are inevitable enough. Students absorb a mass of scientific facts and principles and have only the vaguest idea of how they were produced. If they were asked to discover something new in the world, they would feel most helpless, as, indeed, many university theses indicate.

Our science courses should be altered to instill the scientific method, even at the sacrifice of some factual content.

It is indeed a shameful thing to live in the scientific age and yet not to understand science, but to vaunt a handful of accumulated facts instead. How much worse to teach science courses which are only masses of facts and theories, to teach static things instead of the dynamic scientific method of discovering truth.

The following is quoted from the Encyclopedia Britannica, vol. 20, p. 340, 14th Edition, under the heading "Agassiz," to show in contrast what can be done and how it was done in science teaching.

> In America Agassiz's industry and devotion to scientific pursuits were as strongly marked as in Europe, but two other traits here assumed a much greater importance. As a teacher of science he was extraordinarily skillful, certainly the ablest America has ever known. In addition he was personally devoted to his students who were in the highest sense, co-workers with him. . . .
>
> Agassiz's method as a teacher was to give contact rather than information. He discouraged the use of books except in detailed research. Among his favorite expressions were, "If you study nature in books, when you go out-of-doors you cannot find her." "It's not textbooks we want, but students. The book of nature is always open." "Strive to interpret what really exists."
>
> The result of his instruction at Harvard was a complete revolution in natural history study in

* The scientific method in mind is the experimental method as described in the *Encyclopedia Britannica,* Vol. 20, p. 121, 14th edition, under the headings, "Science" and "The Methods and Meaning of Science." To quote it in part, "Even while Bacon was philosophising, the true method was being practiced by Galileo, who, with a combination of observation, hypothesis, mathematical deduction, and confirmatory experiment, founded the science of dynamics." It is the experimental method as exemplified in Newton's "Principia," and in the work of Faraday and hundreds of others. Descriptive science, and statistical interpretation of data are only phases of the complete scientific method.

America. The purpose came to be not a category of facts taken from others, but the ability, through contact, to gather the needed facts. As a result of his activities every notable teacher of natural history in the United States for the second half of the 19th century was at some time a pupil of Agassiz or of one of his students.

The life, the fun, the innate preciousness of science is in the act of advancing knowledge, the thrill of creation, the joy of discovering. Most of the facts learned may well be, and surely will be, forgotten by the average student. But the appreciation, the scientific method, the scientific attitude, the joy of conquest should be taught and carried over to guide and illuminate the student's later life!

It would seem that in science courses it is the teacher's task to help his novices in a scientific rediscovery of the simpler wonders of the world, during which they will become scientists. This can be done only by adopting a teaching procedure that will lead the novice in the footsteps of the great.

Intellectual processes and skills are acquired by practice; students will acquire the scientific processes and skills by doing original research on problems graded to their abilities. The student must have practice in recognizing *problems,* not only as the inevitable annoyances of life but also as interesting puzzles challenging him to solution and discovery. He must become observant enough to find in his experiences: facts, evidences, leads, clues, or *indications* for the solution of his problems. He must be able to use his scientific background of facts and laws, and his own powers of induction to formulate the possible theories, suppositions, *alternatives,* or ways in which the phenomena might be explained. Then he must develop some skill in selecting the alternatives most likely to be correct or most feasible for experimental verification to be his *hypothesis* or working hypothesis. From this hypothesis he must be able to predict various consequences or *deductions* which can be tested by experiment. He must exercise ingenuity in devising the experiment and the control experiment, for without control there is no *verification.* This part of the scientific method requires special care. The experiment is an integral part of the test in the scientific method, its function being to give a definite and conclusive answer to a definite and debatable question which checks the accuracy of the hypothesis. It bears the same relation to the hypothesis as the eating does to the pudding. The hypothesis is the *conclusion,* if verified by the deductions and experiments. If not verified, a conclusion has not been attained. The *application* is in a sense an additional answer to the problem; it is also the fruit of the scientific method. Actual applications of the fact or principle discovered, already in use, are satisfactory from novices; suggestions for original use or inventions are better.

The mass of our voters have no conception of the scientific method and our science students are not getting one. Science, physical or social, can lay small claim to a core position in the curriculum until "science" courses give scientific training.

It would seem advisable then to modify our conventional science report form to make it require: (1) *Problem,* (2) *Indications,* (3) *Alternatives,* (4) *Hypothesis,* (5) *Deduction,* (6) *Conclusions,* (7) *Application,* and *Verification* with: (1) a definite question, (2) a definite answer and (3) at least one control. Appended to this article is a proposed form, filled out by a pupil, to show its manner of use.

Since it is apparent that the present laboratory report form is limited in scope and does not sufficiently comprehend the function of the experiment in the scientific method, it seemed desirable to devise a supplementary form to remedy this deficiency. It is very imperfect, no doubt, but nothing could be found, and it may have great suggestive value.

The *Problem* should be issued as a challenge and, so far as possible, should be one which actively interests the pupil or the pupils of a class. If the students are curious

about weather signs one will get much better results just then in that field than in something extraneous. However, the instructor must exercise at least veto power in the selection of the problem where time and facilities are limited. The problem selected must be such that at least one of the possible alternatives can be readily tested, and it should be a mite outside the scope of the text to prevent peeking.

The *Indications* should be furnished almost entirely by the pupils, even when a little delay and preliminary study is required. It is important that the pupil's preliminary findings and experience be reliable and fairly complete facts, since the *Indications* in a scientific investigation correspond to the clues in a detective story.

The *Alternatives* suggested by the pupils show their acuteness of mind, the thoroughness of their search for indications, and the wealth of their scientific background. All reasonable alternatives or theories should be acceptable; all clever ones should be accepted with enthusiasm. The instructor will show no preference for the supposition he thinks correct but will distribute praise for thoughtful use of the *Indications* at hand.

No reasoning in support of the *Alternatives* is called for by the form, since this reasoning may be quite extensive and is of no importance in the report of an investigation; the experiments are the proof. However, such reasoning is perfectly legitimate in the classroom if it does not get out of hand, and will help stimulate interest and emulation.

Although not incorporated in the form, discussion of the *Alternatives* may be quite pronounced in the classroom while selecting the *Hypothesis*. The part of this discussion that supports the *Alternative* finally selected for the *Hypothesis* may be reported if the pupil or instructor so wishes, under the heading, "Hypothesis."

The pupils should be impressed with the fact that both in the formulating of *Alternatives* and in the selection of the *Hypothesis*, their factual content comes into play. No pupil could suggest deliquescence who had never learned about it from books, other people, or from personal observation. While memorizing and texts remain necessary they now have a clearer basic objective.

In devising the experiments, the ingenuity of the pupils should have full play, subject to the instructor's knowledge of what is feasible with his facilities of time and equipment. As a class activity the pupil whose *Alternative* is finally adopted as the *Hypothesis* should have first chance of proof and will as a rule be ready with some plan. Suggestions, especially criticism, should be very welcome. It is an unfortunate thing to go through with some experiments and then have them shown faulty. The control experiment should be devised at the same time as the main experiment and should generally be what is technically called a "blind experiment" (one which lacks the variable but possesses all the other conditions of the main experiment and in which the variant is not expected to appear). Its adequacy in eliminating other alternatives and sources of error should be subject to the most searching criticism, and be universally acceptable before being adopted. The experiments have to be conclusive; to be satisfactory they must clearly verify or disprove the *Hypothesis* to be tested. The pupil or pupils whose experiment is adopted may well be put in charge of the *Conclusions* and may word this part of the report. The *Deductions* will have appeared spontaneously in the preceding planning of the experiments.

The *Application* again employs the student's factual content. It also reveals ingenuity and it appeals particularly to the boy of an inventive turn of mind. Any reasonable and clear *Application* may be accepted.

In summing up the investigation, the instructor should make a few appropriate remarks, somewhat in the spirit of an after-dinner speech. The pupils should be made to feel that something definitely worth while

Scientific Method Work Sheet

Date March 9, 1937 Name

Unit Weather

Topic The Storm Glass

I PROBLEM — I WONDER whether the barometer measures air pressure, temperature, humidity, ionization, or what (Instructor)

II INDICATIONS — I FIND THAT: 1. My friends' "storm glass's" weather predictions are as bad as the weather bureaus' (Smith).
2. It correlates about as well with the humidity (Jones)
3. " " " " " " temperature (Hughes)
4. " " " " " " static on the radio (Slocum)
5. " " " " " " peacefulness of his rheumatism (Pierce)

III ALTERNATIVES — IT MIGHT BE: 1. Air pressure (Pierce)
2. Humidity (Jones)
3. Temperature (Hughes)
4. Ionization (Brown)
5. Some unknown factor (Smith)
6. Some combination of factors (Ciotti)

IV HYPOTHESIS — MY GUESS IS #1 - air pressure (class vote)

V DEDUCTIONS — IF MY GUESS IS RIGHT, THEN 1. A barometer subject to a vacuum pump would drop lower and lower (Pierce)
2. Another barometer not exposed to the vacuum pump would show no changes. (Pierce)

VI VERIFICATION — MY EXPERIMENT ON THE FOLLOWING PAGE PROVES THAT a barometer does show such effects (Wilbur)
Therefore, a barometer does measure air pressure. (Pierce)

VII APPLICATION — I THINK THIS TRUTH CAN BE USED AS FOLLOWS: 1. altimeter (Howland)
2. In caissons and submarines, a barometer would warn of too great or too rapid a change in pressure. (Bergan)
3. The fault with the weather predicting does not lie in the barometer although it might be just as well to print no words on a storm glass but to leave the interpretations to the readers. (Brilliante)
4. Science can improve transportation and industry (Mason)
5. Science can sometimes predict the weather (Greene)

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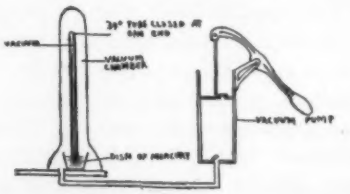
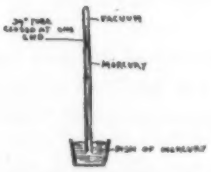
Scientific Method Experiment Sheet

Date March 2 1937 Name

Question Does the Mercury Barometer measure air pressure?

Main Drawing	Control Drawing
	

Main Steps	Main Observations	Control Steps	Control Observations
1. I made a mercury barometer by filling a 34" tube with mercury and inverting it in a cup of mercury, as shown above.	1. The mercury only stood about 30" high when I let no air enter the tube	1. I made another barometer by filling a 34" tube with mercury and inverting it in a dish of mercury, as shown above.	1. The mercury only stood about 30" high when I let no air enter the tube.
2. I placed it in the vacume chamber of an exhaust pump and pumped some air out.	2. The mercury went lower with each stroke of the pump.	2. I did not touch this barometer.	2. The height did not change.
3. I pumped until the mercury went no longer.	3. The mercury stood about 6" high.	3. I did not touch this barometer 56"	3. The height did not change.
Main Steps	Main Observations	Control Steps	Control Observations
4. I let the air back into the vacume chamber	4. The mercury rose immediately to the height of about 30".	4. I did not touch this barometer.	4. The height did not change.
5. I had another girl repeat this experiment.	5. She obtained the same result.	5. I had another girl repeat this experiment	5. She obtained the same result

Answer Yes, the mercury barometer measures air pressure

BECAUSE: 1. The height responded immediately to the vacume caused by the exhaust pump.
2. Control shows that no other factors were at work
3. The greater the vacume (less the pressure) the lower fell the mercury.
4. Since I could not reduce the mercury to zero I believe that a perfect vacume was not produced but that there was a pressure of $\frac{6}{30} \times \frac{15}{1} = 3$ lbs. per sq. inch.

THE CONTROL SHOWS that no other factors were at work

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has been done, discovered (genuinely original to them at least)* and pragmatically proved (the *Hypothesis* has been carefully verified or disproved by the deductions and experiments). If a class activity, the various steps might be chalked up as it proceeds and the name of each student placed with his contribution on every one's report. Something real has been done: something new has been discovered; there is plenty of credit to distribute.

There are indications that the extra time involved in conducting scientific investigations in the scientific way will be well repaid in heightened interest, enthusiasm, and retention, as well as in the acquisition of scientific method, belief, attitude, and skill; also, perhaps, in more thoughtful use of the test. If one regards such an investigation as easily the equivalent of several of the conventional kind, there is no sacrifice of time or effort from any point of view.

This proposed procedure represents a frontal attack on the problem of inculcating scientific belief, attitude, method, and skill. It is felt that attempts to first analyze those characteristics from a psychological point of view have not been particularly fruitful of practical results as yet. But it is thought that the scientific beliefs, methods, attitudes, and skills, regardless of what they may be eventually in psychological analysis, are at any rate attributes of the scientist. Therefore, they can best be developed by making amateur scientists of our students. And this can be done only by giving them genuine scientific research work, problems original to them at least, to be solved by them by means of the scientific method. This should not require more than one or two periods a week, simply replacing the present routine laboratory and demonstration work which most teachers feel to be sadly lacking in meaning and vitality.**

There has not been time and opportunity as yet, to perform satisfactory controlled experiments testing the theoretical superiority of this work sheet in instilling these traits, but such work will be done.

It is hoped that some of the readers of this article will communicate with the author and cooperate in testing this technique.

* The first six investigations in one high-school chemistry class took about six hours and produced three discoveries that were new to the class and the instructor at least, if not to the world. Assuming that their chemicals were pure, they discovered:

(a) Manganese Dioxide is not a genuine catalyst with potassium chlorate as it will produce oxygen if heated alone.

(b) Ferro-Ferric Oxide is a very satisfactory catalyst, however.

(c) 6 grams of Ferro-Ferric Oxide mixed and heated with 6 grams of Manganese Dioxide in a Pyrex test-tube will produce about 100 cc. of some rather inert gas not yet identified.

** The combined Work and Experiment sheets seem to make excellent forms for book reports on scientific investigations, using such references as "Microbe Hunters," "Men Against Death," and the Metropolitan Life Insurance Company pamphlet, "Health Heroes Series—Walter Reed."

MATHEMATICAL REQUIREMENTS FOR THE FIRST COURSES IN GENERAL COLLEGE PHYSICS

KARL F. OERLEIN

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PROBLEM

This investigation was conducted as a project of the American Association of Physics Teachers through its committee on *Student Preparation in Mathematics and College Requirements for the General Course in Physics* of the American Association of Physics Teachers.[1] The study attempts: (1) To ascertain the minimum stated mathematics required for entrance to college, (2) to ascertain the additional mathematics required, if any, for registration in the first courses, and (3) to ascertain the adequacy of this required mathematics.

The institutions on the approved list for 1933–34 of the Association of American Universities were selected for the study. The Association divides its list into four groups: Group I, includes 30 large member universities; group II, 11 smaller non-member universities; group III, 30 technical institutions; and, group IV, 202 colleges. A total of 273 institutions, representing all sections of the country, and Canada and Hawaii were on the list.

[1] Oerlein, K. F. *Mathematical Requirements for the First Courses in General College Physics*, doctor's thesis, University of Pennsylvania, 1937.

FINDINGS

The Entrance Mathematics. From the official college catalogues, 330 entrance specifications in mathematics from 264 institutions were studied. Only the minimum requirements for Arts and for Engineering were recorded. Three-fourths of the institutions stated but one specification for admission.

The range extended from zero to four units of mathematics. The "none required" group was a rather harsh interpretation of the minimum entrance requirement in mathematics as stated in the catalogues. In Figure 1, it is seen that nearly 41 per cent stated two units as the minimum. Notice the bimodal distribution.

Separating, however, the specifications for Arts from those for Engineering, the

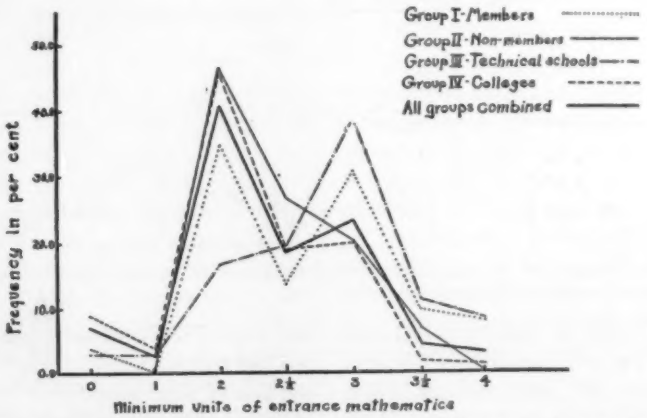

FIG. 1. The percentage distribution of 330 minimum specifications in entrance mathematics stated for admission by 264 institutions.

data showed that 63.7 per cent stated two units for the Arts group and 53.0 per cent stated three units for the Engineering group as the minimum. Figure 2 shows the distribution.

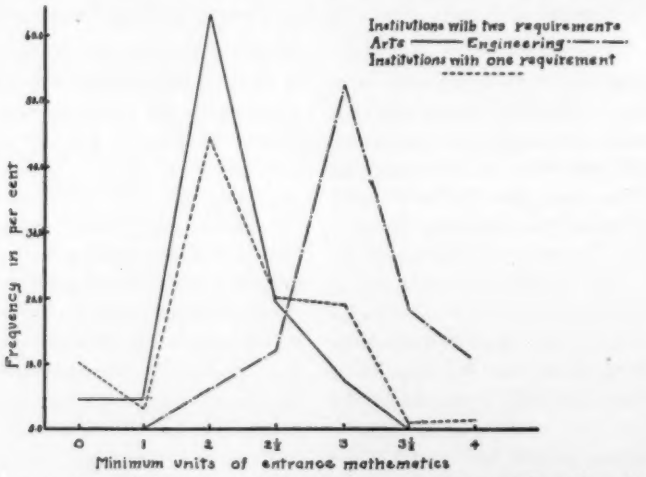

FIG. 2. The percentage distribution of the minimum entrance mathematics stated for *Arts*, for *Engineering*, and for institutions with but one entrance requirement in mathematics.

The average minimum for the same groups were, respectively, 2.04 and 3.08, while for all institutions it was 2.29 units.

three units of minimum entrance mathematics to be?

For the two-unit group, Table I shows that 80.0 per cent stated one unit of algebra and one unit of plane geometry. For the three-unit group, Table II shows that 43.6 per cent stated one and one-half units of algebra, one unit of plane geometry and one-

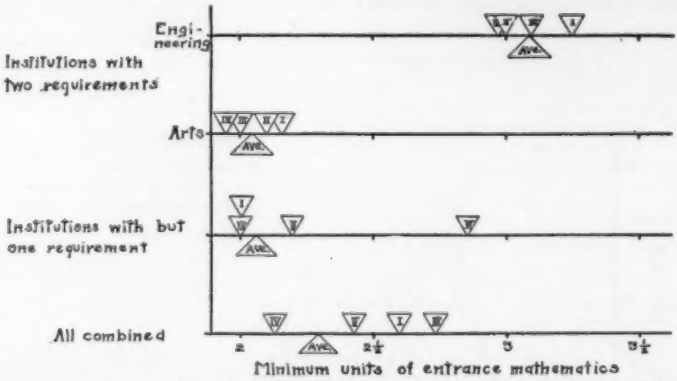

FIG. 3. The averages of the minimum entrance mathematics for institutions with one and with two requirements in mathematics for admission.

Notice, in Figure 3, that for technical schools with but one entrance specification the average was still nearly 3 units, which bears out the fact that engineering schools require more mathematics. In what specific branches of mathematics were these two and half unit of solid geometry; while another 41.1 per cent stated two units of algebra and one unit of plane geometry.

This mathematics represents approximately two and one-half to three and one-half years of secondary school mathematics.

The Prerequisite Mathematics. How much additional mathematics did the departments of Physics require for registration in the first course in College physics? A 77.3 per cent response to a printed form sent directly to the departments of physics furnished, among other things, reliable data on the prerequisite mathematics for 351 first courses.

The average of the prerequisite mathematics for all courses was approximately a semester of college mathematics.

The entrance mathematics was now compared with prerequisite mathematics. There was evidence that the prerequisite mathematics increased as the entrance mathematics increased.

The average minimum mathematics stated as required for all courses is equivalent to approximately three to four years of instruction in mathematics. Is this sufficient mathematics for work done in the first courses?

TABLE I

THE MATHEMATICS SPECIFIED BY 135 INSTITUTIONS WITH A TWO-UNIT MINIMUM IN ENTRANCE MATHEMATICS

Combinations	*Institutional Group*				*Total Cases*	*Per Cent*
	I	*II*	*III*	*IV*		
Algebra 1; Plane geometry 1	15	7	5	81	108	80.0
Algebra 2	..	.	.	1	1	0.7
Not designated	3	.	1	22	26	19.3
Institutions in Group	18	7	6	104	135	100.0

TABLE II

THE MATHEMATICS SPECIFIED BY 78 INSTITUTIONS WITH A THREE-UNIT MINIMUM IN ENTRANCE MATHEMATICS

Combinations	*Institutional Group*				*Total Cases*	*Per Cent*
	I	*II*	*III*	*IV*		
Algebra 1½; Plane geometry 1; Solid geometry ½	7	3	10	14	34	43.6
Algebra 2; Plane geometry 1	5	.	2	25	32	41.1
Algebra 1; Plane geometry 1; Solid geometry ½; Trigonometry ½	2	.	.	.	2	2.5
Algebra 1½; Plane geometry 1; Trigonometry ½	.	.	.	1	1	1.3
Not designated	2	.	2	5	9	11.5
Institutions in Group	16	3	14	45	78	100.0

A first course in general college physics was defined as one that could be taken without previous college physics, included the usual subjects, mechanics, heat, light, electricity, magnetism, and sometimes sound, and for which college credit was allowed.

The stated prerequisites, which extended from none to calculus corequisite, were graded into six levels as indicated in Table III. Approximately one-half of the courses required no additional mathematics for registration; one-quarter required trigonometry; about one-fifth required, at least, the completion of analytics.

The Adequacy of the Stated Mathematics. Probably the most accurate method to get the mathematics used in the first courses would be to actually attend the 351 courses and tabulate from day to day the mathematics used. Instead, laboratory manuals prepared primarily for local use were selected for analysis. "Home made" manuals were chosen for three reasons:

(a) Since they were prepared with local conditions and specific objectives in mind, they probably conformed more nearly to the type of mathematics used in the local course than anything that could have been gathered and studied.

TABLE III

THE FREQUENCY OF THE STATED MATHEMATICAL PREREQUISITE, EXPRESSED IN LEVELS, FOR 351 FIRST COURSES

Prerequisite Mathematics Level	*Institutional Group*				*Total Times Stated*	*Per Cent*
	I	*II*	*III*	*IV*		
1. None	31	5	11	106	153	43.5
2. High school physics only	1	2	1	12	16	4.6
3. Corequisite, freshman mathematics	1	2	0	24	27	7.7
4. Prerequisite, through trigonometry	12	3	15	56	86	24.5
5. Prerequisite, through analytics	11	2	7	23	43	12.3
6. Corequisite, calculus	4	4	7	11	26	7.4
Total	60	18	41	232	351	100.0

(b) A large number were being used, and

(c) as far as the literature revealed, they had not been studied before.

Of the institutions responding, 139 or, approximately, 60 per cent used local manuals. Less than 30 per cent used published manuals exclusively.

Seventy-two manuals from 61 institutions containing 3117 experiments were collected and studied. This represents a 43.8 per cent sampling of the number of local manuals reported.

The experiments were classified under 138 headings. One-third of the headings accounted for two-thirds of the experiments. There was a definite indication that a set of core experiments has come to be recognized as suitable for the first courses.

The mathematical analysis of these manuals revealed a number of points:

1. Laboratory physics is decidedly quantitative. Mathematical skills, abilities and facts were so interwoven with the theory of the experiments that it was difficult, in some cases, to isolate them from the context of the experiment. Functionalized mathematics was abundantly illustrated in laboratory physics.

2. Slightly more than one-half of the manuals contained material properly called "mathematical introduction." This material fell into four groups. In order of frequency these were:
   Significant figures
   Measures of accuracy—study of errors
   Curve plotting
   Miscellaneous

3. Algebra up to the solution of simple simultaneous quadratics was found. One and one-half units of secondary algebra covered all but a few of the items found.

4. The use of plane geometry was confined to the elemental concepts of points, lines, angles, triangles, parallelograms, circles, and so forth. One unit of secondary plane geometry covered all the relationships found.

5. The use of trigonometry was almost exclusively confined to the use of the sine, cosine, and tangent. Some of the more difficult manuals used a few identities. The amount of trigonometry found hardly warrants a college course in trigonometry.

6. In the more difficult manuals some analytics was found. The range, however, was restricted to graphical representation on rectangular, polar and logarithmic papers, the analytics of the straight line and, in a very few cases, the rectangular hyperbola.

7. The amount of calculus found was exceedingly small, and then, only in a few of the most difficult manuals.

An extensive comparison was next made between the mathematics actually found in the manuals and the mathematics stated to be required for the courses. This comparison revealed that there were no serious discrepancies between that used and that implied by the requirements, except for the most difficult manuals. There was, however, much scattered evidence that the deficiencies for these difficult manuals were

met by increased mathematical prerequisites, extra class time, supplementary instruction sheets, pamphlets and so forth.

A comparison was now made between the mathematics in the manuals and that found by Congdon[2] in a widely used textbook. As far as specific skills, abilities and facts were concerned, the agreement was good, except for analytics and calculus. The manuals used more analytics and calculus than the textbook did, thus emphasizing that, in the manuals the mathematics was not only more functionalized, but that its range was greater also.

A comparison of the mathematical vocabularies showed the manuals to contain a third more words and expressions than the textbook. This larger vocabulary further emphasized the greater mathematical range of the manuals. These comparisons showed the manuals to be, at least, as good a source from which to obtain the mathematics used in the courses as the textbook, perhaps even better.

The investigation gave evidence that the stated mathematical requirements for the first courses were adequate in the light of the mathematics used in the manuals, hence in the courses, too. The failure of students who have credit in the stated requirements to do the mathematics in physics, should no longer be attributed to lack of exposure to mathematics.[3] One is thus forced to the conclusion that, either these students have not mastered the mathematics for which they have been granted credit, or, the mathematics was not made sufficiently applicable to the mathematical situation in physics.

The author wishes to acknowledge his indebtedness to the department of physics of the University of Pennsylvania and particularly to Dr. Thomas D. Cope, Professor of Physics.

TEACHING BEGINNING ZOOLOGY WITHOUT DISSECTION

ARAVILLA MEEK TAYLOR
Lake Erie College, Painesville, Ohio

The idea of teaching beginning Zoology in college without required dissection was suggested by a study of changes in secondary school science courses, which indicated a dearth of Zoology courses offered in our high schools.

Why, we questioned, do we have the paradoxical situation of so little demand for the subject of Zoology, although there are many students intensely interested in animals? How much are the methods employed in teaching Zoology (in particular the requirement of dissection) responsible for this paradox? Are not our high school and beginning college classes made up of students needing general knowledge of numerous topics, rather than an intensive, specialized knowledge of a few?

If these methods are responsible, we are not only making it impossible for our Zoology college graduates to find teaching positions in their chosen field, but, what is perhaps a more serious matter, we are depriving a large portion of our students of even an introduction to the animal world in which they might find so much of interest and value. The number of our Biological positions is determined by the number of students entering beginning classes, because these students in turn determine,

[2] Congdon, Allan R. *Training in High School Mathematics Essential for Success in Certain College Subjects.* New York: Bureau of Publications, Teachers College, Columbia University, 1930.

[3] Oerlein, K. F. "Mathematical Difficulty in College Physics," *Mathematics Teacher,* 30: 125–127; March, 1937.

either directly or indirectly, the demand for the work, and therefore the number of teachers required in the years to follow.

The freshman course in Zoology at Lake Erie College has been organized with the interests of the general student in mind, rather than the specific requirements of those students who have already decided to specialize in science. The biological principles applicable to the study of all living organisms are included, unless, as happens to be the case with us at present, the Zoology is preceded by a semester of Botany. This makes it unnecessary to do more than make the obvious correlation.

At the first session each student is given a typewritten copy of the main points on which credit for the course will be based. These are essentially as follows:

1. Ability to follow oral and written directions.
2. Ability to correlate laboratory work with lectures and text.
3. Ability to do independent work.
4. Ability to plan arrangement of work when opportunity to do so is given.
5. Ability to make good use of laboratory time. (Indicated by methods of study and application to work at hand.)
6. Accuracy in representing objects to be drawn, and correctness in labeling drawings when such work is required.
7. Power of observation and ability to apply it even when not specifically told to do so, as in the study of extra material, charts, models, on field trips, *etcetera*.
8. Neatness and order of laboratory sheets and written work.
9. Promptness in finishing and handing in any required work.
10. Knowledge of and judgment in use of outlines, charts, tables, *etcetera*, as aids in recording data.
11. Knowledge of subject matter.

The class is informed that the final grade will be made up of approximately one third laboratory grade, one third class grade which will include any oral or written tests, and one third the final examination grade. It is impressed upon the students that the first two grades are determined during the progress of the semester's work.

It is neither feasible nor necessary to present here an outline of our course in great detail. We begin with the Protozoa and continue through the ten most important Phyla. In each Phylum we study as many forms as the time will permit. Drawings are made of one or more examples, and sometimes of special structures. The number of drawings and the number of types in each case is determined by the structures found most desirable for fixing in mind the characteristics of the group, and by the amount of variation in the group.

Drawing takes time, it is true, but we are convinced that there is something to be gained by coordination of eye and hand in the exact representation of an object or a structure, which is difficult to secure otherwise. There is also a very real and desirable feeling of satisfaction which comes to a student who completes a creditable original drawing, which is entirely absent when a ready-made drawing is merely labeled. But we are equally convinced that this would not prove the best plan in all schools. In larger institutions, with the more varied types of students this might be only a waste of time, and prepared drawings would be much more practical. We also find them very satisfactory in advanced work where the student has learned to study materials efficiently without drawing.

Charts, models, and other helps are used to show characteristics not easily understood from the actual animals. A considerable amount of preserved, mounted, or living material belonging to the Phylum under consideration is displayed conveniently in the room. Students are encouraged to examine this in order to acquire a broader view of group characters than is possible from a more intensive study of one form. From time to time they may be required to make charts, tables, or outlines based on this material. These give information not indicated in the drawings and offer practice in the use of such devices.

Books (and other printed matter) are placed in the laboratory for reference in an effort to eliminate dependence upon one

authority. From class lectures, texts, a limited amount of outside reading, and field trips the student receives information regarding behavior in natural habitats, economic importance, whatever internal structure seems essential to the comprehension of the group as a whole, interrelations and interdependence of animals, and of animals and plants, and other interesting and useful factors related to the animal world. This will necessarily overlap to some degree the work in the laboratory, but the two are intended to supplement each other rather than to duplicate.

The weekly quiz sections are small and are frequently more in the nature of conferences than that of set tests. The laboratory work is arranged to fill the scheduled time of four regular class periods per week without dissection. However we never have a class without several members who express the desire to make some dissections, even though it may mean extra time on their part. In some cases this work may be substituted for some other problem. We usually first offer the opportunity for dissection in the Phylum Annulata. In a recent class, for example, consisting of twenty-eight students there were eighteen who made one or more dissections. Several in the group dissected fully as many forms as are required in most dissection courses. But, it is quite significant that among those eighteen, as well as among the other ten, were several who assured us that they would have avoided the course entirely had dissection been *required*. This adds strength to the conviction that there are numerous students, uninterested in or even repelled by the old type of course, who may profit by this arrangement and may become interested to the extent of overcoming a dislike for dissection.

Several possible questions and difficulties presented themselves. The following are some of the most important of these together with the answers based on our experiences:

1. *Would students transferring to other schools at the end of the freshman year find the lack of practice in dissection a handicap?*

While we do not feel that our work should be planned primarily for such students, we realize that, as in all colleges, there are likely to be some students who will make such a change at the end of the first year. Perhaps the best answer to the question may be a simple statement of the fact that to date no complaint has yet reached our department regarding such difficulty having occurred in the case of transfers. If the students have continued in Zoology they have evidently not suffered in comparison with their fellows; if they have not continued in that field, the difficulty has not developed.

2. *Would this lack also prove troublesome to students attending summer school elsewhere and taking Zoology work?*

The students who have taken such courses have been able to compare very favorably with other members of their classes, and have received "above average" grades. They have reported that they were better able to carry the work than were many of their classmates because of their more intensive training in observation and in laboratory drawing. (These students attended summer sessions in regular courses in large state universities.)

3. *Would it be possible to obtain enough factual material of college grade to occupy advantageously the time allotted?*

Our problem has been, not in finding sufficient interesting and profitable material, but in eliminating the least valuable so that we could cover the work we thought should be included, and yet finish by the end of the semester. We can see the possibilities for a full year of work without dissection, should we ever have the opportunity to offer such a course.

4. *Are there enough other benefits to be obtained from laboratory work if we eliminate the training in technique offered by dissection? What, after all, are the benefits to be derived from the work in the labora-*

tory where we spend such a large portion of our time?

There are many benefits to be derived from the time spent in the laboratory if the time is properly employed. Those which seem most important to us are stated under the plan of work already given and need not be listed here. These points of emphasis should be somewhat adaptable, and those which prove most desirable in one school or at one time may not be the best for other conditions of time or place. We are satisfied that we are obtaining desirable results with our present emphasis now, but stand ready to modify our plan when changes in conditions justify such modification.

5. *Would such a plan in any way lower the standing of the institution in which it was introduced, especially if that institution happened to be a college for women?*

The only way in which a point of this sort could be determined was by making the experiment and watching the results. The answer would lie in the quality of work done by students when and if they elected to continue similar work elsewhere.

The plan has now been in force twelve years. Up to the present, we have had no reports from transfers, summer school students, graduate students, students in medical schools or schools for nurses, which would indicate that our students are not as well equipped for later work as are those from other colleges. This in itself is sufficient evidence that our standing as an institution has not been lowered in any way by our change of plan.

6. *What effect would a change of this kind have upon the election of Zoology in later college years?*

It has probably caused only a slight increase, if any, in the number of students concentrating in Zoology, since most of these would have no great antipathy for dissection in the first place. Our purpose has not been to increase the number of Biology majors, but to increase the number of students who receive at least a glimpse of the attractions offered by the study of animals.

7. *Could sufficient training in dissection technique, and sufficient knowledge of internal structure be given to students who wished to continue with Comparative Anatomy, to enable them to carry on in medical school, schools for nurses, or in graduate work in Zoology after receiving the A.B. degree from Lake Erie?*

In our second year's work, Comparative Anatomy of Invertebrates and Vertebrates, dissection is stressed. We find no delay as a result of omission of dissection in the first course. On the contrary, we find that students often do better work because of more training along other lines.

In summarizing may I say that the purpose of a non-dissectional beginning course in Zoology is not primarily to increase the number of advanced students in Zoology, although we are always pleased to have our numbers augmented. Nor is it that we want or need an easier course; our course is not easier. The purpose has been bred from the strong impression of the desirability for more knowledge of animal life among a greater number of people; from the deep conviction of its importance as an avocational interest; and from its direct relation to the continuation and increase of Zoology positions for the teaching profession.

Classroom Notes

Aids for the biology teacher.—*Display Boards:* Display boards which are a modification of Riker boxes may be made for thin, flat specimens such as flowers and leaves. A heavy cardboard back and a thin sheet of cotton batting forms the foundation under the specimens. The transparent cover may be a plate of window glass of appropriate size which is bound to the board back by binding tape. An unbreakable board may be made by substitution of celluloid sheets for the glass. In this case a special glue is needed to fix the tape to the celluloid. The glue, which is similar to commercial products called cold or liquid solder, is made by dissolving celluloid in acetone. A transparent tooth brush handle will dissolve in acetone overnight. Use 2 or 3 ounces of acetone, depending upon the thickness of glue you desire to make.

Chart Construction: Charts made on heavy paper are poor economy because the paper has neither strength nor durability. Commercial chart cloth, which is the ideal material, demands a price that is often prohibitive. A cheap and durable substitute for chart cloth is waterproof sign cloth. This material is available at art supply shops at about 30c per yard. Since the cloth is 54 inches in width a single yard of the material makes a good sized chart. This cloth, prepared for outdoor signs, holds its body under all atmospheric conditions. There is no coating which peels off. Ink and paint penetrate the fibres and will not wash off. Pencil, crayon, ink and paint can be used with ease since the surface is not slippery. A good chart may well sacrifice detail for diagrammatic simplicity. The line should be bold in width and color. India ink applied with a broad tipped drawing pen proves most satisfactory.

On diagram charts it is often desirable to omit labels so that each structure may be indicated as the lesson is developed without distraction of pupil attention to other portions of the drawing. An unlabeled chart may prove useful for review or examination lessons.

Skull and Skeleton Preparation: After the specimen is skinned, dip it for a few seconds into boiling water then lacerate the cooked flesh. Repeat the process until all flesh has been removed. Brushing the bone with a stiff brush aids in the removal of small particles. After the bone is completely clean it may be bleached by boiling for a short time in soap solution.

Paraffin sculpture: The common art of soap carving has proven a valuable aid to teachers in presenting three-dimensional conceptions of biological subjects. Soap sculpture, however, has disadvantages in that it is monochromatic and that it deteriorates rapidly. Household paraffin offers neither of these limitations, yet is available at slight cost, and yields readily to the knife. The extremes of Minneapolis climate have produced no noticeable effects upon the paraffin sculpture done at University High School.

After the carving is complete, melted Crayola wax crayons may be used as paints to color the various structures. This polychrome innovation was originated by Miss Florence Smythe, art instructor at University High School.

The technique of paraffin sculpture is excellent for portrayal of anatomical details, especially of microorganisms where the study with microscope and picture usually fail to portray depth.

Simple lantern slides: Cellophane lantern slides work well for the presentation of short tables, quotations or messages which may be typed. Place a 3¼ x 4 inch sheet of cellophane between a carbon paper twice that size, but folded (with carbon faces inward) to fit the cellophane sheet. Type the message on this triple sheet. A clear, sharp, impression of the type will be formed on both sides of the cellophane paper. Place this transparent sheet between two clear lantern slide plates and bind edges with tape.

Ground glass plates for lantern use are available at Kodak supply houses. Diagrams, graphs, quotations, etc., may be drawn on the plates with pencil, colored pencil or ink. Simple line drawings may be traced from books by placing the translucent plates directly over the source picture. After the plate has served its purpose it may be reclaimed by washing off soluble inks or removing pencil marks with a rubber eraser. The ground glass plates produce no glare.

Museum jar preparations: Biological specimens in sealed museum jars command such a prohibitive price that supply houses have found it necessary to offer screw top specimen jars at much more reasonable rates. However, the cost of preparation, packing and transportation of these cheaper specimen jars still demands a price often incompatible with the school budget. For economy it is desirable to collect and prepare your specimens of local fauna and flora, thus saving budget monies for purchase of exotic or rare forms. Both teacher and pupils profit by the experience and interest developed by cooperative collecting of local organisms and their preparation for the school museum.

A very desirable container for general museum use is the 32-ounce, tall, straight-sided, clear glass mayonnaise jar, equipped with 83-millimeter,

continuous thread, paraffin-paper-lined, black enameled cover. Cut a glass plate to fit the jar diagonally from the bottom of one side to the top of the opposite. Heavy, white linen thread, inconspicuously drawn through the tissues, is tied about the plate to support the specimen. The preservative solution is ordinarily 10% formalin. Sponges, whose spicules dissolve in formalin, should be preserved in alcohol.

The organs of dissected specimens should be pinned in positions desired for best observation, lungs and bladder may be inflated, and the whole preparation should be allowed to harden in 10% formalin for a day before removing the pins. The organs will retain their positions without support. The specimen may be mounted on the glass plate as described above.

Exotic forms may be bought in bulk and neatly mounted for the museum by teacher and pupils. Such specimens may be obtained at a fraction of the cost of commercial museum preparations. The author has a list intended as a guide to the neophyte teacher in the choice of rare or exotic specimens.

LESLIE BERGREN,
Univ. of Minnesota High School

Qualitative Experiments with the Lever.—After several unsuccessful attempts of trying quantitative lever experiments both as demonstrations and student experiments, the following qualitative experiment has been substituted with excellent results.

HOW DOES THE LEVER SAVE EFFORT?

Procedure for first class lever.

a. Balance the meter stick on the fulcrum. Place a 200 g weight at the 80 cm mark and press down at the 10, 20, 30, and 40 centimeter marks. Where is more effort required? Where is less effort required?

b. Balance the meter stick on the fulcrum. Place the weight at the 90 cm mark and press down at the 10 cm mark. Repeat moving the weight to the 80, 70, and 60 centimeter marks, but always press down at the 10 centimeter mark. Where is more effort required? Where is less effort required?

c. Place the weight at the 90 centimeter mark and press down the the 10 centimeter mark in all parts of (c). Use the following positions for the fulcrum: 20 cm, 30 cm, 40 cm, 50 cm, 60 cm, 70 cm, and 80 cm. Where is more effort required? Where is less effort required?

d. Review the answers to the two questions at the end of a, b, and c. Write a general statement to tell the positions of weight, effort, and fulcrum so that the effort will be as little as possible. You may want to use the words effort arm and resistance arm in the general statement.

Procedure for second class lever.

a. Place the fulcrum at the 10 centimeter mark. Place the weight at the 40 cm mark. Lift at the 50, 60, 70, 80, 90, and end of the meter stick (100 cm mark). Where is more effort needed? Where is less effort needed?

b. Place the fulcrum at the 10 cm mark. Place the weight at the 20 centimeter mark. Lift at the end of stick (100 cm mark). Repeat moving the weight to the 40, 60, and 80 centimeter marks, but always lift at the end of the bar. Where is more effort required? Where is less effort required?

c. Place the weight at the 50 cm mark and lift at the 90 cm mark in all parts of (c). Use the following positions for the fulcrum: 2 cm, 10 cm, 20 cm, 30 cm, and 40 cm. Where is more effort required? Where is less effort required?

d. Same as (d) for first class lever. Use answers for a, b, and c of the second class lever.

Procedure for third class lever.

a. Place the fulcrum at the 10 cm mark. Place the weight at the 90 cm mark. Lift at the 20, 40, 60, and 80 cm mark. It may be necessary to hold the meter stick on the fulcrum by pressing down directly above the edge of the fulcrum. Where is more effort required? Where is less effort required?

b. Place the fulcrum at the 10 cm mark. Place the weight at the 80 cm mark. Lift at the 40 cm mark. Repeat moving the weight to the 70, 60, and 50 cm marks, but always lift at the 40 cm mark. Where is more effort required? Where is less effort required?

c. Place the weight at the 90 cm mark and lift at the 60 cm mark in all parts of (c). Use the following positions for the fulcrum: 10 cm, 20 cm, 30 cm, 40 cm, and 50 cm. Where is more effort required? Where is less effort required?

d. Same as (d) for the first class lever. Use answers to a, b, and c of the third class lever.

Final Conclusions. Review your answers to (d) of the three classes of levers. Write a general statement of your conclusions that will be true for all classes.

The above experiment is used in ninth-grade general science classes before anything but definitions of terms of the lever and general concepts of work and energy are developed.

E. THOMPSON RICHARDSON,
Springfield High School,
Springfield, Penna.

Editorials and Educational News

ANNUAL MEETING OF THE NATIONAL ASSOCIATION FOR RESEARCH IN SCIENCE TEACHING

The Atlantic City portion of the annual meeting of the N. A. R. S. T. will be held February 27, 28, and March 1. Headquarters have been established at the Madison Hotel. The tentative program consists of the annual dinner on Sunday, February 27, a panel discussion of means for obtaining problem solving through science on Monday, February 28, and the presentation of recent research studies in science education on Tuesday, March 1. Abstracts of these studies will be sent to all members prior to the meeting.

An additional meeting, planned in cooperation with the National Council on Elementary Science, precedes the Atlantic City meeting. This meeting will be held at Philadelphia, February 25 and 26. Full details of both meetings will be made available in the complete program which will appear in a later issue of this journal.

INSTITUTE FOR PROPAGANDA ANALYSIS

Science teachers and administrative officers will be interested in the formation of the Institute for Propaganda Analysis, Inc. The announcement of the organization is contained in the first *Monthly Letter to Help the Intelligent Citizen Detect and Analyze Propaganda,* published in October, 1937. Quotation of three paragraphs from the letter will give the major purposes of the new group:

> *Institute for Propaganda Analysis* is a nonprofit corporation organized for scientific research in methods used by propagandists in influencing public opinion. The institute will conduct a continuous survey and analysis of propagandas. By objective and scientific scrutiny of the agencies, techniques, and devices utilized in the formation of public opinion, it will seek to show how to recognize propaganda and appraise it.
>
> There is today especial need for propaganda analysis. America is beset by a confusion of conflicting propagandas, a Babel of voices, warnings, charges, counter-charges, assertions, and contradictions assailing us continually through press, radio, and newsreel. These propagandas are disseminated by political parties, labor unions, business organizations, farm organizations, patriotic societies, churches, schools, and other agencies; also by word of mouth by millions of individuals.
>
> If American citizens are to have clear understanding of conditions and what to do about them, they must be able to recognize propaganda, to analyze, and to appraise it.

In the second monthly letter, November, 1937, attention is directed to ways of detecting propaganda. Seven common propaganda devices are listed and analyzed. The prefatory statement in this second letter is as follows:

> We are fooled by propaganda chiefly because we don't recognize it when we see it. It may be fun to be fooled but, as the cigarette ads used to say, it is more fun to know. We can more easily recognize propaganda when we see it if we are familiar with the seven common propaganda devices. These are:
>
> 1. The Name Calling Device
> 2. The Glittering Generalities Device
> 3. The Transfer Device
> 4. The Testimonial Device
> 5. The Plain Folks Device
> 6. The Card Stacking Device
> 7. The Band Wagon Device

It would appear from these letters that the new organization has taken steps to carry out a much-needed program of search into propaganda of various kinds. It is hoped that the true spirit of scientific research will carry forward the good work. If, through objective analysis of the ways and means of propaganda, the organization does enlighten the intelligent citizen, progress will have been made in the direction of substituting open-mindedness and discovery

of truth for prejudice or bias and acceptance of emotionalized utterances. The address of the organization is 132 Morningside Drive, New York City.

PROGRAM OF THE FIFTH ANNUAL MEETING OF THE AMERICAN SCIENCE TEACHERS ASSOCIATION AFFILIATED WITH THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

INDIANAPOLIS

DECEMBER 29, 30, 1937

Wednesday Evening Session, December 29, 6:30 P. M.; Columbia Club.

Dinner and Conference of Board of Directors.

Thursday Morning Session, December 30, 9:30 A. M.; Ball Room, Columbia Club.

Chairman: Earl R. Glenn, State Teachers College, Montclair, N. J.

Symposium Topic: New Knowledge of Matter.

1. Some Physical and Biological Consequences of the Discovery of X-Rays.
   Arthur H. Compton, University of Chicago.
2. Recent Discoveries Concerning the Virus Diseases.
   W. M. Stanley, Rockefeller Institute for Medical Research, Princeton, N. J.
3.* Properties of the Isotopes of Hydrogen and Nitrogen.
   Harold C. Urey, Columbia University.

Thursday Luncheon, December 30, 12:30 P. M., Ball Room, Columbia Club.

Chairman: Otis W. Caldwell, General Secretary A. A. A. S., Yonkers, N. Y.

The luncheon speaker will be George D. Birkhoff, President of the American Association for the Advancement of Science.

Thursday Afternoon Session, December 30, 2:00 P. M.; Ball Room, Columbia Club.

Chairman: Harry A. Carpenter, Rochester Public Schools, Rochester, N. Y.

Symposium Topic: The Need for a Twelve Year Science Program for American Public Schools.

1. From the Viewpoint of a State University and Its Laboratory Schools.
   Ralph K. Watkins, University of Missouri.
2. From the Viewpoint of Experimental Schools in City Systems.
   Mary Melrose, Cleveland Public Schools, Cleveland, Ohio.
3. From the Viewpoint of Colleges that Train Teachers for Rural Schools, Villages, and Towns.
   W. C. Croxton, State Teachers College, St. Cloud, Minn.
4. From the Viewpoint of High Schools Enrolling Many Students Who Do Not Expect to Attend Colleges.
   George L. Bush, South Side High School, Cleveland.
5. From the Viewpoint of the Interrelationships of National, State, and Local Science Organizations, and Clubs.
   A. Otis W. Caldwell, Yonkers, N. Y.
   B. Edith R. Force, Tulsa, Okla.
   C. Morris Meister, New York City Schools, N. Y.
6. Business meeting. Reports of Committees. Election of Officers.
7. Evening meeting of Board of Directors.

* Subject to change.

Officers:

President—Harry A. Carpenter, Rochester Schools, 501 Genesee St., Rochester, N. Y.
First Vice-President—Earl R. Glenn, State Teachers College, Montclair, N. J.
Second Vice-President—Jerome Isenbarger, 3400 N. Austin Ave., Chicago, Ill.
Secretary—Harry A. Cunningham, Kent State University, Kent, Ohio.
Treasurer—Homer W. Le Sourd, Milton Academy, Milton, Mass.

Special Lectures by Scientists at the American Association for the Advancement of Science. Indianapolis, Indiana, December 27, 1937, to Jan. 1, 1938.

Monday, Dec. 27, 1937.

Dr. Edwin G. Conklin, Emeritus Professor, Princeton University.
Address: Science and Ethics.
(Address to be given Monday evening.)
Murat Temple: Auditorium.

Tuesday, Dec. 28, 1937.

Dr. Charles A. Kraus.
Gibbs Lecture: The Present Status of the Theory of Electrolytes.
Ball Room, Antlers Hotel.
(Tuesday afternoon at 4:30 P. M.)

Dr. Irving Langmuir, Research Department of the General Electric Company, Schenectady, New York.
Sigma Xi Lecture: Biological Applications of Surface Chemistry.
(Address to be given Tuesday evening.)
Murat Temple: Auditorium.

Wednesday, December 29, 1937.

Dr. George Lyman Kittridge, Cambridge, Mass.
Phi Beta Kappa Lecture: Shakespeare and the Critics.
(Address to be given Wednesday evening.)
Murat Temple: Auditorium.

Thursday, December 30, 1937.

Dr. Thomas Parran, Surgeon-General of the United States Public Health Service.

Address: Syphilis as a Public Health Problem.

(Address to be given Thursday evening.)

Murat Temple: Auditorium.

SYMPOSIUM ON SCIENCE AND SOCIETY AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

INDIANAPOLIS, INDIANA

DECEMBER 27, 1937, TO JANUARY 1, 1938

FUNDAMENTAL RESOURCES AS AFFECTED BY SCIENCE

Session I. Controlling Factors in Economic Development.

Session II. Natural Resources.

Paper 1. Agricultural and Forest Resources.

Paper 2. Mineral Resources.

Session III. Power and Capital Resources.

Paper 1. Power Resources.

Paper 2. Capital Resources.

Session IV. Human Resources.

Paper 1. Man Power.

Paper 2. The Utilization of Human Resources.

Session V. The Applications of Science to Business.

Paper 1. Scientific Methods in Business Organization.

Paper 2. Research Laboratories and the Spirit of Science.

SCIENTIFIC EXHIBITS OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, INDIANAPOLIS MEETING, 1937

The exhibition of scientific apparatus and books will be of unusual interest to all teachers of science. This feature of the meetings will be worthy of careful study. A more detailed account will appear in the magazine, *Science*, as published by the association.

RECENT SCIENCE COURSES OF STUDY

Amarillo, Texas. Elementary Science. Grades 4, 5, 6. 1937.

Appleton, Wisconsin. Conservation. Elementary Schools. 1937.

California State. Science Guides for Elementary Schools. Ornamental Shrubs, Fresh Water Aquaria. Vol. II. 1936.

Fort Smith, Arkansas. A Teacher's Manual of Pupil Guidance in Science for Elementary Grades. 1937.

Fresno, California. Elementary Science. Grades 1–6. 1937.

Los Angeles, California. Study Outlines for the Eighth Year Science, Division of Instruction and Curriculum. September, 1935.

Los Angeles, California. The Progress of Science. A–10. 1936.

Los Angeles County, California. This Living World. Teachers Guide. Ninth Year Science. School Publication No. 287. 1936.

Los Angeles. Trees in Our Neighborhood, Elementary Schools. 1935.

Malden, Massachusetts. Course of Study in Science for Junior High School. 1936.

Manila, Philippine Islands. Course of Study in Biology. 1937.

New Rochelle, New York. Living Things and Where They Live. Grades 1 and 2. 1934.

Pasadena, California. Elementary Science in the Elementary School Curriculum. 1936.

Pittsburgh, Pennsylvania. Biology. High School. 1936.

Shorewood, Wisconsin. Science Units Grade 6. 1937.

Abstracts

SCIENCE EDUCATION—GENERAL

POWERS, SAMUEL RALPH. "Influences of Science on Human Activities with Implications for Education." *Educational Method* 38: 395–401; May, 1937.

The author discusses the following contributions from science to an understanding of the influences affecting intellectual and emotional life and the potentialities of this contribution to the use of intelligence in human activities: (1) The physical universe; (2) Life; (3) Interrelations and interdependencies; (4) Control; and (5) Epistemology. The author suggests the desirability of investigations relating to: (1) The processes of generalizing which are necessary and inevitable in life; and (2) scientific methods. —C.M.P.

DALE, EDGAR. "Children's Questions as a Source of Curriculum Material." *Educational Research Bulletin* 16: 57–66; March 17, 1937.

Children's questions have been very little utilized in curriculum construction. The first part of this report briefly reviews several of the investigations that have been made to determine children's science interests. The last part of this report gives the resumé of a study of children's interest in health education and the utilization of these interest questions in the construction of a health education curriculum. —C.M.P.

CRAIG, GERALD S. "Science and Elementary Education." *Teachers College Record* 38: 660–677; May, 1937.

The elementary school is undergoing conspicuous changes, notably in such matters as teacher-pupil and school-community relationships, and in the evolution that is in progress in regard to what constitutes the curriculum. In the emerging curriculum, science will have an integral part. The author follows this treatise with a discussion of the values to be derived from a well-rounded program of elementary science. Four types of activities must play an important part in the teaching of elementary science in the future: (1) Discussion; (2) Experimentation; (3) Field Trips; and (4) Reading. Specialists are needed in many systems, less as departmental specialists and supervisors than as consultants. —C.M.P.

FITZPATRICK, F. L. "Pupil Testimony Concerning Their Science Interests." *Teachers College Record* 38: 381–388; February, 1937.

This is the resumé of an investigation made to determine the individual's consistency of response on identical items after a three-month interval. Complete records were obtained from 199 individuals, distributed among the following classes: a graduate college class in biology, a college freshman class in physical science, a tenth grade biology class, eighth and seventh grade classes in general science, and a fifth grade class in elementary science. Several general results were as follows: (1) The average individual changed his or her testimony to a marked degree after a three-month interval; (2) Change of testimony regarding identical items was also characteristic of whole groups. College students were no more consistent than the other groups; (3) Group testimony did not indicate a marked preference either for the physical sciences or for the biological sciences; (4) No marked sex differences were found. The author concludes "Taken as a whole the bulk of pupil testimony gave evidence of being unstable, inconsistent, ill considered and unreliable." —C.M.P.

SMITH, ALPHEUS W., TYLER, RALPH W., AND HEIL, LOUIS M. "Evaluation of Student Achievement in the Physical Sciences." *The American Physics Teacher* 5: 102–107; June, 1937.

This is a resumé of an investigation made by the authors in evaluating student achievement in the physical science fields of physics and astronomy. The first part of the article discusses the philosophy and point of view leading to the work and the elements of evaluation procedure. The initial steps in the effort to evaluate student achievement centered about the problem of deciding on the objectives for the course. These objectives became the framework of the course and were as follows: (1) Understanding of major ideas; (2) Interpretation of data; (3) Application of principles; (4) Recognition of assumptions; (5) Development of skills; and (6) Sensitivity to social implications of the physical sciences. Advantages of the evaluation procedure: (1) Diagnosis of student difficulties; (2) Understanding of objectives by students; (3) Effect on the teacher; and (4) Source of specific information on pupils for other teachers. —C.M.P.

RIGGS, CECIL O. "Motion Pictures Available for Use in Physics Instruction." *The American Physics Teacher* 5: 127–129; June, 1937.

The author lists by title, 125 films that are available for use in physics classes. —C.M.P.

FRUTCHEY, F. P. "Retention in High School Chemistry"; "Illustrative Test Exercises in High School Chemistry." *Educational Research Bulletin* 16: 34–37; 122–126; 140; February 17, and May 19, 1937.

These two reports are the resumé of a study made to determine retention in high school chemistry. In the study, students were tested as they began high school chemistry, as they completed high school chemistry, and one year after completing high school chemistry. The objectives for which the achievements of the students were tested were: a knowledge of facts and principles; a knowledge of symbols, formulas and valence; balancing chemical equations, and the application of chemical facts and principles. One year after completing the course the pupils remembered 84 per cent of the gain they made in information during the course. Retention of application of facts and principles was 92 per cent. Retention of chemical terms was lowest—66 per cent. —C.M.P.

DAFFIN, JOHN B. "Why the Woman Student Does Not Elect Physics." *The American Physics Teacher* 5: 82–85; April, 1937.

Science enrolments in 36 colleges for women showed 16.5 per cent were enrolled in biology; 9.18 per cent in chemistry; and 5.09 per cent in physics. Possible reasons for greater election of biology and chemistry: (1) Chemistry and biology have more obvious applications to life; (2) Chemistry is more colorful; (3) Greater feeling of accomplishment in biology and chemistry; (4) Use of mathematics; (5) Physics teachers in high school poorly prepared and kill all interest in physics; (6) Nature of physics course presented. —C.M.P.

HOFFMAN, JOSEPHINE. "News Notes." *Educational Screen* 16: 221–222; September, 1937.

Under the subheading "Students Learn Technique of Projection" is described something of the training in visual education given at the Indiana, Pennsylvania, State Teachers College. A list of something over a hundred vocabulary items pertinent to the techniques of slide and motion picture projection is given. This would serve as an excellent check-list for those interested in developing special work in this field. The problems of projection are so often laid at the door of the science teacher if the institution does not maintain a special position for supervision of this work. Every student at this Pennsylvania institution must pass this course in visual education before a certificate to teach in the state is granted.

Another "News Notes" item is a review of recent additions to the Erpi film library. Nineteen new pictures have recently been completed. Two new series have been inaugurated for elementary schools. A series in Human Geography includes "Our Earth, Animals in Modern Life, Clothing, Shelter, Water Power, Conservation of Natural Resources, A Backward Civilization" which are intended for fourth, fifth and sixth grades. Three new films in the Physical Science Series are "Velocity of Chemical Reactions," "Catalysis" and "Colloids," produced under the direction of the University of Chicago staff, as is also a biology film "Reproduction Among Mammals." A physics film on "Light" has been produced under the direction of Dr. H. S. Sheldon, of New York University, for use on the High School level.

Educators and Traffic experts have endorsed a safety-instruction film "America's Safety City" produced in cooperation with Evanston's Bureau of Accident Prevention, along lines suggested by officers of the N.E.A. and the National Congress of Parents and Teachers, and the National Safety Council. Most of the material was obtained by Evanston, Illinois, police in six years of movie taking on the streets of that city. It is claimed that this film is so effective that accidents have been reduced 60 per cent in localities where children saw the picture. —O. E. Underhill.

ANDERSON, O. S. "Complete Learning Through Visual Aids in Physics." *Educational Screen* 16: 249–251; October, 1937.

Six essential points are listed which must be kept in mind in a Visual Aids Program. Various forms of presentation should be adopted depending on the type of picture. A number of specific pictures are listed according to the way in which they may be used. A number of these pictures are discussed individually and specific suggestion made as to how they may be utilized in a physics course. Among the current releases reviewed, those of a special interest to the science teacher are (1) *Seeing the Universe Through the World's Largest Telescope*, a five reel series giving a complete outline of descriptive astronomy, issued by the Educator's Film Library, 1600 Broadway, New York City. These are available in 16 or 33 mm. sound or silent. (2) The first of a series of films *Getting Your Money's Worth* dealing with fraud and misrepresentation practices upon the public. The films show how articles and commodities are tested, and advice is given on how to guard against misleading enterprising statements. Technical supervision is in the hands of Arthur Kallet, author of "100 Million Guinea Pigs." 16 mm. sound prints will be available for school. —O. E. Underhill.

"1000 And One Best Films." *The Educational Screen*, Chicago, Illinois. 1937. 75c. (25c to subscribers of the *Educational Screen*.)

This is the 13th annual edition of the Blue Book of non-theatrical films. The format has been changed to make handling and reading easier. This edition lists all new subjects reported, together with the films from previous issues that are still most actively circulated, and proved to have permanent value. These listings are classified into 145 subject groups. —O. E. Underhill.

ELEMENTARY SCIENCE

BRAUER, OSCAR; ENGWICHT, HARRY; GREENE, EARNEST S., AND MORELAND, WILLARD H. "Communication." *Science Guide for Elementary Schools* 3: 1–54; December, 1936.

This issue is devoted to the following phases of communication: Direct Communication by Sound; The Telegraph; The Telephone; and Wireless or Radio. —C.M.P.

MARSH, L. ALDEN. "Programs for Nature Clubs." *The Instructor* 46: 15, 80; March, 1937.

The President of the Counselors of the School Garden Association of America discusses Nature Club programs as to values and kinds. —C.M.P.

GUNDERSON, AGNES G. "A Unit on the Bakery." *The Instructor* 46: 16; 78–79; March, 1937.

This is a second-grade integrated unit as a part of a broader theme "Community Helpers in Our City." —C.M.P.

MORSE, STANLEY W. "Water, Its Conservation and Use." *Science Guide for Elementary Schools* 3: 1–38; March, 1937.

This elementary science bulletin discusses: (1) Occurrence of water; (2) Sources of water; (3) Natural water; (4) Hard water; (5) Living impurities in water; (6) Purification of water; (7) The water situation in California; (8) How water is obtained for human use; and (9) Other uses of water. There are 39 experiments included in the content material. —C.M.P.

HELM, EMMA J. "The Mississippi Valley." *The Grade Teacher* 64: 22–23, 92; April, 1937.

This is an illustrated unit with special reference to floods and flood control. —C.M.P.

MAKOUSKY, LAURETTA. "Power." *The Grade Teacher* 64: 20–21, 79–82; April, 1937.

This unit relates how the various sources of power have been developed, how various devices for the production and utilization of power were invented and how the bringing of natural resources under man's control has brought changes in our ways of living. —C.M.P.

SMITH, HELEN. "Stratosphere Balloons." *The Grade Teacher* 64: 39, 71; April, 1937.

This is an activity unit in elementary science adapted for use in the primary grades. —C.M.P.

CUNNINGHAM, JUANITA. "Trees and Seeds." *The Grade Teacher* 54: 82–83; May, 1937.

This is an elementary science unit for the primary grades, consisting of tests that may be used for seatwork. —C.M.P.

TOWNSEND, EVELYN L. "Bird Homes." *The Grade Teacher* 54: 28; May, 1937.

This is a nature study lesson on the homes of birds, for the primary grades. Homes of the wren, robin, oriole, sparrow and quail are illustrated. —C.M.P.

MAY, WILMA GUNN. "Bird Study." *The Grade Teacher* 54: 39, 80–81; May, 1937.

This intermediate grades unit discusses local birds, how birds travel, parts of the birds, bodies, what birds wear, homes of birds, what birds eat, value of birds, enemies of birds and senses of birds. —C.M.P.

WILLCOX, ISOBEL. "Progress by Invention." *The Grade Teacher* 64: 14–15, 82–83; March, 1937.

This is a unit that traces the advances made by inventions. There are several interesting illustrations. —C.M.P.

BLOUGH, GLENN O. "Studying Airplanes." *The Instructor* 47: 51–60; September, 1937.

This is an excellent illustrated teaching unit on airplanes, with material for the primary, intermediate, and upper grades. Lesson units, activities and a bibliography are included. —C.M.P.

HUSSONG, CLARA. "September Nature Lessons." *The Instructor* 47: 32, 83; September, 1937.

A brief unit for the middle and upper grades on plant and animal life especially observable in September and October. —C.M.P.

BLOUGH, GLENN O., AND BRINK, IDA K. "The Study of Magnets." *The Instructor* 47: 25, 84–85; October, 1937.

This elementary science unit presents twelve experiments that may be performed in the elementary school, together with general information about magnets, uses of magnets, pupil activities, correlation with school subjects, outcomes, and a bibliography. —C.M.P.

SAWYER, EDMUND J. "Hollow Tree Homes." *The Grade Teacher* 55: 16–17, 97; September, 1937.

This is an elementary science unit on animals that have homes in trees. Among the animals discussed are ducks, flying squirrels, bears, owls, hawks, tree frogs, and various birds. Illustrated. —C.M.P.

GREEN, CHARLOTTE HILTON. "Migration." *The Grade Teacher* 55: 14–15, 82–83; October, 1937.

This is a unit on migration of birds, discussing probable causes, routes, height, speed, distances covered, how birds are guided, and perils of the way. —C.M.P.

JULIAN, KATHERINE L. "The Story of Foods." *The Instructor* 47: 41–50; November, 1937.

This is an illustrated unit, presenting materials for classroom use on each grade level. Self-checking study lessons and a bibliography are included. —C.M.P.

DAVIS, C. B. "Queer Flying Things." *The Grade Teacher* 55: 16–17, 88; November, 1937.
This unit considers the following flying animals: bat, fish, frog and squirrel. It is suggested that this nature study lesson be made the approach to the study of airplanes. —C.M.P.

SCIENCE

VAN LOON, HENDRIK WILLEM. "The Story of Salt." *Natural History* 39: 79–98; February, 1937.
This is an excellent article for supplementary reading in general science and chemistry classes. Salt has long been and still is, one of the most valuable of commodities. There are several excellent photographs. —C.M.P.

ANDREWS, ROY CHAPMAN. "Consider the Dinosaur." *Scientific American* 156: 149–152; March, 1937.
Dinosaurs were long of body but short of intellect, and the reasons why he died out are not exactly known. *Brontosaurus* attained a length of 65 to 70 feet and weighed about 25 tons. He lived on several hundred pounds of vegetables a day. But he had a brain of only two and a half ounces. When the lakes dried up he died. He was too highly specialized to change his habits; too big to migrate. Tons of flesh, small head, feeble teeth—he could not adapt himself to even a slight change in the world about him. The largest dinosaur yet discovered was the *Brachiosaurus* of Colorado and East Africa—100 feet in length; the smallest, *Anchisaurus*, the size of a chicken. —C.M.P.

VANCE, JOHN FRAZIER. "What Brings Them Home." *Scientific American* 156: 154–157; March, 1937.
The author says "Today no one can tell you why a homing pigeon comes home." However we may be on the verge of finding out. The author discusses several observations made on homing pigeons. In August, 1931, a homing pigeon was set free in France and 24 days later it arrived home in Saigon, Indo-China, 7,200 miles away. Pigeons were used extensively in the World War—and now are used by many important newspapers to carry news and photographs. —C.M.P.

SIMPSON, GEORGE GAYLORD. "How Fossils are Collected." *Natural History* 39: 329–333; May, 1937.
This is an interesting, illustrated article on the collection and preservation of fossils. —C.M.P.

WISSLER, CLARK. "Twilight of the Old West." *Natural History* 39: 307–317; May, 1937.
This article gives personal glimpses from the memories of an anthropologist revealing the West of the Indian and the final struggle of a primitive race in the grip of the white man's reservation. The Indian population of the United States in 1861 was about 249,707; in 1936, 334,003. —C.M.P.

ALLEN, ARTHUR A. "Hunting with a Microphone the Voices of Vanishing Birds." *The National Geographic Magazine* 71: 696–721; June, 1937.
This article describes the author's experiences in recording the voices of some of America's vanishing birds which may soon follow the extinct Great Auk, Labrador Duck, Passenger Pigeon, and Heath Hen. There are 32 illustrations. —C.M.P.

New Publications

LYNDE, CARLETON JOHN. *Science Experiences with Home Equipment.* Scranton, Pa.: International Textbook Company. 1937. 226 p. $1.25.

The two hundred science experiences described in this book require only home equipment. The author has had many years teaching experience in which the experiments described in this book were given innumerable trials. As he says in the preface "They have been tested many times and all are sure fire. You will succeed in every case, if you follow the directions." There are several pages in the back of the book explaining the scientific principles involved in each experiment.

The reviewer knows of no book of simple scientific experiments that approaches this one. The reviewer can recommend this book with a "money back if not satisfied" guarantee. It will prove a joy to every teacher of elementary science, general science, and secondary science—the very book so many have been looking for.

Professor Lynde retires at the end of this year as Professor of Physics and Household Engineering at Teachers College of Columbia University. He is author of the well-known *Everyday Physics.* Based as it is on his many years of teaching experience this book makes a fitting epitaph to a most successful teaching career. —C.M.P.

KRUH, FRANK O., CARLETON, ROBERT H., AND CARPENTER, FLOYD F. *Modern-Life Chemistry.* Chicago: J. B. Lippincott Company, 1937. 734 p. $1.80.

If one were to judge the progressiveness of the various sciences by the type of textbooks extant, one could without hesitancy consign physics and chemistry to the category "most conservative." In this decade of changing textbooks they have made least change. General science and biology have long ago swung over to the unit idea of presenting subject-matter. Chemistry and physics have done so only imperceptibly, usually only in name. The authors of this text are to be congratulated on doing a first-class job of writing a chemistry text based on the unit idea. They have divided each unit into four main divisions: (1) "Unit assignment"; (2) "Unit problems to be solved"; (3) "Optional material for the unit"; (4) "Unit recitation and test." Each unit usually has four or five problems. There are eleven units as follows: (1) "Foundations of Chemistry"; (2) "The Structure of Matter"; (3) "Solutions and Near-solutions"; (4) "Chemical Action in Solution"; (5) "Chemical Equations and Calculations"; (6) "Sulfur and Its Compounds"; (7) "The Halogens and the Periodic Classification"; (8) "The Nitrogen Family"; (9) "Mineralogy and Chemistry"; (10) "Metallurgy and Chemistry"; (11) "Organic Chemistry." End-of-unit references might possibly be more useful than end-of-text references.

The authors are high-school classroom teachers of chemistry. The late Frank Kruh taught chemistry in the Soldan High School, St. Louis; Mr. Carleton teaches in the Summit, New Jersey, High School; and Mr. Carpenter in the Stivers High School of Dayton, Ohio. —C.M.P.

FRAPRIE, FRANK R. *The American Annual of Photography 1938.* Boston: American Photographic Publishing Company, 1937. 332 p. $1.50.

Real amateur photographers everywhere always look forward to the appearance of this Annual, and they will not be disappointed in this 1938 number. It has about 100 pictorial illustrations and a series of excellent articles on various phases of photography. Among topics discussed are: The technique of the exposure meter; The use of the range finder in nature photography; What contrast has this paper; Testing of emulsions and developers by the amateur; The mystery of photographic developers; A universal amidol developing formula; and so on. Formula for several developing solutions are included. —C.M.P.

GRAY, GEORGE W. *The Advancing Front of Science.* New York: Whittlesey House, McGraw-Hill Book Company, 1937. 364 p. $3.00.

This is probably the best of the science books yet published under the caption "Whittlesey House." And the others may all be rated excellent. This is a Scientific Book Club selection and may well be described as one of the best interpretations of science that has yet been written. In this book the author takes the rôle of a reporter of news rather than as a summarizer of history. Each chapter has been read and checked by an authority in that field. The chapter headings are: "New Horizons," "Frontiers of Earth," "The Shining Stars," "Skies Are Reddening," "The Encircling Darkness," "The Cosmic Bombardment," "Deeper into the Atom," "The Science of Sound," "Chemistry Advancing," "A Chemist on Vacation," "Life Begins," "Machines Which Imitate Life," "Thinking Machines," "Chemistry and Thinking," "Can We Live Longer," and "The Promise of Science."

Thus the book deals with all fields of science, reporting recent progress made possible by newly developed precision machines. Many little-known

but vastly significant advances are revealed. The author makes one feel, as all scientists do, that the laboratory is the most romantic and the most significant workshop on this mite of an earth of ours.
—C.M.P.

HARDING, ARTHUR M. *Astronomy.* Garden City, N. Y.: Garden City Publishing Company, 1935. 481 p. $1.98.

This is one of the most readable and interesting books on popular astronomy that the reviewer has read. The author truly brings "the splendor of the Heavens down to earth." Dr. Harding is Professor of Mathematics and Astronomy at the University of Arkansas and a lecturer of note on popular astronomy, both on the platform and on the radio.

The chapter headings are as follows: "Our Flying World," "The Sun and His Realm," "Other Worlds Than Ours," "Our Lunar Companion," "Signs and Wonders," "The Story of the Stars," "The Depths of Space," and "An Astronomer Looks at His Universe."

Some of the numerous illustrations and diagrams are the best to be found any place. The treatment of the mythology side of the study of stars, and the folk-lore and primitive beliefs that are involved, is especially commendable. This book is excellent supplementary reading material for science survey courses, and elementary science and general science teachers. —C.M.P.

HOSKINS, R. G. *The Tides of Life.* New York: W. W. Norton and Company, 1933. 352 p. $3.50.

This is undoubtedly the most readable and, at the same time, authoritative book that has been written on the fascinating theme of endocrinology. The endocrine glands are truly the regulating tides of the body. Hormones represent the most important development in the field of medical science since the discovery of the bacterial origin of disease. A New Physiology dates from the time of their experimentally proven effects. What we are—physically, mentally, sexually, emotionally—depends in no small measure upon the functioning of our endocrine glands. "A pinch too little of thyroxine spells idiocy. A pinch too much spells raving delirium." The potency of the hormones is almost unbelievable. "In the present they cooperate in determining the forms of our bodies and the workings of our minds. In the past they may have set the pattern of our advancement through the ages." Racial variations may well have been due to variations in hormone secretions. Future discoveries in this field would seem to offer the best hope for a lengthened, a more livable old age.

The author, an authority in this field, is Director of Research of the Memorial Foundation for Neuro-Endocrine Research, Harvard Medical School.

The Tides of Life is written in a most delightful, readable style and is recommended most highly as a reference book for high-school biology classes, and for college biology and survey courses.
—C.M.P.

BEAUCHAMP, WILBUR L., FOGG, HARRIET M., CRAMPTON, GERTRUDE, AND GRAY, WILLIAM S. *Science Stories, Book III.* Chicago: The Reilly and Lee Company, 1937. 256 p. $1.25.

This book should prove even more popular than its two predecessors. The book has been checked for scientific accuracy by two very capable biologists: O. D. Frank, of the University of Chicago High School, and Leon L. Pray, of the Field Museum. Its adaptability for elementary children has been checked by the following specialists in elementary sciences: Irene Sauble, of the Detroit elementary schools, Joe Young West, East Redford, Virginia, and Glenn O. Blough, of Greeley, Colorado.

Numerous illustrations in color should provide unusual child-appeal. These illustrations are indeed a work of art. No previous books in a similar field have been the equal of this one in aesthetic appeal.

The four parts of the content material are as follows: (1) "Where do living things dwell?" (2) "How are living things protected?" (3) "The earth's surface; and (4) "How is work made easy?" —C.M.P.

BOYD, WILLIAM. *An Introduction to Medical Science.* Philadelphia: Lea and Febiger, 1937. 307 p. $3.50.

This book gives an aeroplane view of disease. It covers the nature and causes, the effects on the various organs and systems, and finally the diagnosis and prevention. While purely introductory and brief, yet the book is adequately comprehensive. Technical terms have been reduced to a minimum.

The first section of the book deals with the general principles of disease, the second with the diseased organs, and the third with some practical applications. There are numerous and excellent illustrations.

In difficulty, the textural material is not beyond the comprehension of high-school students. It is a book the reviewer has long been looking for and is highly recommended as a supplementary book for the biology survey course, or the course in physiology. —C.M.P.

CASWELL, HOLLIS L., AND CAMPBELL, DOAK S. *Readings in Curriculum Development.* New York: American Book Company, 1937. 753 p. $3.00.

Readings in Curriculum Development presents a critical selection of reference material relating to curriculum development. Criteria used in selecting the material include: (1) Authority of the source; (2) Clarity and effectiveness; (3) Range of point of view; (4) Availability of

the source; and, (5) Recency of the source. Two hundred and seventy-one readings are grouped under one of the following divisions: (1) "Challenge of contemporary life to the school"; (2) "The social responsibility of the school"; (3) "Significant influences on curriculum development"; (4) "Concepts of the curriculum"; (5) "Principles basic to curriculum development"; (6) "Aims of education"; (7) "Scope of the curriculum"; (8) "Pupil purpose"; (9) "Activities for realization of purpose"; (10) "Grade placement and time allotment"; (11) "Selection of subject matter"; (12) "Teaching procedures"; (13) "Evaluating the outcomes of instruction"; (14) "Organizing instruction"; (15) "Unit basis for organizing instruction"; (16) "The course of study"; and, (17) "Administrative consideration." —C.M.P.

NORTON, JOHN K., AND NORTON, MARGARET ALLTUCKER. *Foundations of Curriculum Building.* Boston: Ginn and Company, 1936. 599 p. $3.00.

The purpose of the book is to bring together from many sources materials most pertinent to curriculum building at the elementary school level. It takes account of various theories of curriculum building, presents a practical synthesis of research findings and draws upon the results of advanced practice. Science teachers will find the following chapters most pertinent: (1) The why of curriculum revision; (2) Underlying issues in curriculum construction; (3) Various approaches to the selection of curriculum content; (4) Contributions of research to curriculum building; (5) Trends in curriculum building; and, (6) Science. —C.M.P.

CARLSON, ANTON J., AND JOHNSON, VICTOR. *The Machinery of the Body.* Chicago: The University of Chicago Press, 1937. 580 p. $4.00.

This is one of the University of Chicago series of New Plan Texts. It emphasizes human physiology, bringing out clearly the essential similarity of the human machine and that of other animals. It is an execllent text for use in a course in general physiology or for use as a supplementary reading text for the science survey course. For such courses, it is probably the best supplementary reader now available. It could also be made of great value in secondary biology courses, especially in the advanced courses. The book is very readable, and the large, clear print, excellent illustrations, and chapter summarizations make it a most usable book. The materials relating to hormones, enzymes, the circulatory and digestive systems are especially well presented. —C.M.P.

DITMARS, RAYMOND L., AND BRIDGES, WILLIAM. *Wild Animal World—Behind the Scenes of the Zoo.* New York: D. Appleton-Century Company, 1937. 302 p. $3.00.

Did you read *Snake Hunter's Holiday, Thrills of a Naturalist's Quest,* or *Strange Animals I Have Known?* If so, that will be sufficient reason for your wanting to add this latest Ditmars book to your high-school shelf. And when you have read this one, you will want to add the others. Dr. Ditmars is the well-known Curator of Mammals and Reptiles at the New York Zoological Park and the world's outstanding authority on reptiles.

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VISHER, STEPHEN S. *Aids to the Student of Conservation.* New York: John Wiley and Sons, Inc., 1937. 32 p. $0.25.

This pamphlet contains a series of questions designed to accompany Parkins and Whitaker's *Our Natural Resources and Their Conservation.* There are 12 review questions and 8 thought-provoking questions for each of the 22 chapters. —C.M.P.

MOULTON, FOREST RAY. *Consider the Heavens.* Garden City, New York: Doubleday, Doran and Company, 1935. 322 p. $1.98.

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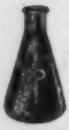

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